NASA

Seventh SEMIANNUAL REPORT TO CONGRESS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON 25, D. C.

JANUARY 1 – JUNE 30, 1962

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To the Congress of the United States:

Pursuant to the provisions of the National Aeronautics and Space Act of 1958, as amended, I transmit herewith a report on the projects and progress of the National Aeronautics and Space Administration for the period of January 1 through June 30, 1962. This is the seventh of these reports since the passage of the legislation establishing that Agency.

This report covers a period of acceleration in the national space program and reveals the significant role of the National Aeronautics and Space Administration in that progress. Congressional support and interagency cooperation have contributed substantially to this record of space and aeronautics performance.

John F. Kennedy

The White House,
March 4, 1963

SEVENTH SEMIANNUAL REPORT TO CONGRESS

JANUARY 1 THROUGH JUNE 30, 1962

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON 25, D.C.

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THE PRESIDENT, February 8, 1963

The White House.

DEAR MR. PRESIDENT: This Seventh Semiannual Report of the National Aeronautics and Space Administration, covering the period January 1 through June 30, 1962, is submitted to you for transmittal to the Congress in accordance with section 206(a) of the National Aeronautics and Space Act of 1958. The first part of this report summarizes NASA accomplishments and progress; the second part discusses them in detail.

During this period, an increasingly substantial number of industries, educational institutions, privately supported research organizations, and Government facilities joined with NASA in the drive to achieve this Nation's goal of preeminence in space. The accomplishments of these combined resources, as recorded in this report, give assurance that the national space program is making significant progress and will continue to enhance the Nation's prestige and benefit its economy.

Respectfully,

JAMES E. WEBB,
Administrator.

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The Period in Review—

A Summary

Summary

During this reporting period, NASA drove toward achieving for this Nation the President's goal of preeminence in space. Substantial progress was made in marshalling the Nation's industrial, Government, and university resources and molding them into an efficient and cohesive space-oriented complex.

Acting to meet the critical requirement for more powerful operational launch vehicles, NASA reprogramed additional funds to accelerate modification of the Michoud plant, Louisiana, where the first stages of the Saturn C–1 and the Advanced Saturn C–5 will be manufactured, and to provide advanced ground-test facilities at Marshall Space Flight Center, Ala., for the C–5; acquired land for a national large launch vehicle test facility in Mississippi; and moved to establish an operational base for the manned lunar program at the Atlantic Missile Range. At Houston, Tex., construction was started on the Manned Spacecraft Center which will serve as the focal point for manned spacecraft development, flight operations, and astronaut training.

In terms of vehicle development, NASA negotiated additional contracts for development of the Saturn C–5; arranged for highly specialized industrial support to assist in performing systems analyses and in insuring overall checkout, reliability, and integration of the Apollo spacecraft and vehicle system, and initiated contracts for fabrication of the Apollo guidance system. To maintain the required technological advance inherent in the Apollo program, NASA provided increased funding for the F–1 (LOX–JP) and J–2 (liquid oxygen-liquid hydrogen) engine development. The Agency also initiated development of the 1.2-million-pound-thrust M–1 liquid oxygen-liquid hydrogen engine and reviewed industry proposals for the predevelopment studies of the Nova launch vehicle concept.

NASA continued to cooperate with the Department of Defense and the Atomic Energy Commission on joint projects. This Agency is receiving the support of the DOD in adapting the Titan II for the Gemini project; also, in April, an office was established within NASA to maintain liaison with the Air Force Systems Command. And NASA and AEC worked jointly to advance the NERVA and RIFT projects.

To expand industry and university participation in the national space program and to broaden the Nation's base of technical compe-

tence, NASA took part in numerous State and regional business and industrial meetings, and established as a policy the practice of publicizing subcontractor and small-business opportunities.

Also, NASA concluded plans for an 8-week space science summer study at the State University of Iowa. This joint study effort was conducted from June 17 to August 10, under the guidance of the National Academy of Sciences; it enabled scientists from all parts of the Nation to exchange ideas with NASA officials. Its objective: that the space program could benefit from the contributions and counsel of the total scientific community, and the scientific community, in turn, could better understand the Nation's space objectives.

In this period, NASA launched the first orbiting solar observatory (OSO–1), a complex spacecraft to transmit information about solar radiation, and the United States-British Ariel, a satellite to investigate the ionosphere and its relationships with the sun. In addition to these successes, other research satellites, geoprobes, and sounding rockets contributed valuable data in astronomy and geophysics.

Throughout the period, NASA continued to make available to other Federal agencies—including the Department of Defense, the Federal Aviation Agency, and the Weather Bureau—the results of its scientific and technical investigations.

Overall, NASA maintained the sense of urgency required in the accelerated space program recommended by the President and authorized by Congress.

MANNED SPACE FLIGHT

NASA conducted two manned three-orbit flights in the Mercury project; continued spacecraft fabrication and mission planning for Project Gemini; and advanced its studies of the mission techniques for the lunar-landing Apollo project.

On February 20, 1962, the Mercury project spacecraft Friendship 7, piloted by Astronaut John H. Glenn, Jr., successfully completed the first U.S. manned orbital flight, a three-orbit mission. Three months later, on May 24, Astronaut Malcolm Scott Carpenter accomplished a second three-orbit mission and added to the knowledge derived from Glenn's flight.

Following these flights, NASA proceeded with plans for subsequent Mercury missions, scheduling the third flight to make as many as six orbits and extending the manned flight program to include the "one-day mission." These flights will provide additional data on human reaction to longer periods of weightlessness and evaluate both the spacecraft systems and the Mercury range network. During this period, NASA began modifying four Mercury spacecraft to increase the quantity of life-supporting consumables for the longer flights.

In Project Gemini, NASA continued actions leading to initial test launchings scheduled for late 1963 and target rendezvous missions in 1964 and 1965. The Agency let contracts for (1) the two-man spacecraft, which will retain basic features of the Mercury capsule and will also have ejection seats for launch pad emergencies; and (2) the Titan II vehicle, now being modified to launch a manned spacecraft.

In Project Apollo, NASA continued to evaluate the three potential modes for the initial manned lunar-landing mission—direct ascent, earth orbit rendezvous, and lunar orbital rendezvous. (Subsequent to the close of this reporting period, NASA announced the selection of the lunar orbital rendezvous technique as the mode for the Apollo mission and began design studies for the lunar excursion module (LEM). This module will be used to land two of the three-man Apollo crew on the moon; the third will remain aboard the orbiting Apollo command module. Following the exploration period, the two astronauts will launch the LEM and rendezvous in lunar orbit with the command module. After the explorers board the command module, the three astronauts will make the return flight to earth.)

Apollo spacecraft design and development work is now underway. Further, NASA selected contractors to design certain major subsystems, including the telecommunication system, the stabilization and control system, and the guidance and navigation system.

The Apollo flight test program was rapidly becoming a firm schedule, leading to the first flight tests of the boilerplate command module in late 1963. Tests already scheduled will evaluate the launch-escape system, launch vehicle development, and the launch vehicle-spacecraft interaction.

This rapid progress in launch vehicle, ground facility, and spacecraft development will be maintained in order to achieve the national goal of landing a team of explorers on the moon and returning them to earth within this decade.

LUNAR AND PLANETARY PROGRAMS

NASA's unmanned lunar and planetary programs—Ranger and Surveyor, for exploration of the moon; and Mariner and Voyager, for investigations of Venus, Mars, and interplanetary space—continued to progress despite several unsuccessful flights.

Ranger 3 and Ranger 4 were launched. These were the first two in a series of spacecraft designed to impact the moon and send back to earth data on the lunar environment. Both failed to complete their missions. Ranger 3, which missed the moon and went into solar orbit, provided gamma ray data and engineering information. Ranger 4, which landed on the moon, was unable to transmit information because of an electronic failure.

NASA tested and checked out Ranger 5 (similar to Rangers 3 and 4) in preparation for launch in 1962 and continued developmental work on Rangers 6, 7, 8, and 9, which will carry more complex television equipment.

Also, the Agency continued the development of spacecraft for its advanced lunar program: (1) the Surveyor lander, to make a soft landing on the moon and send back data on the lunar surface and environment, and (2) the Surveyor lunar orbiter.

The Jet Propulsion Laboratory fabricated two Mariner spacecraft for fly-by flights to Venus and completed preliminary plans for the more advanced Mariners which will fly by Mars and gather data from that planet.

NASA continued studies on Voyager, its most advanced planetary spacecraft. Proposed for launch by a Saturn-class vehicle about 1966, Voyager would orbit Mars and land a capsule on the planet.

APPLICATION AND SCIENTIFIC SATELLITES

During this reporting period, U.S. satellites supplied data for weather analyses and forecasts, televised pictures from coast to coast, and studied the complex relationships between the earth and the sun.

Meteorological satellites furnished data for operational weather analysis and forecasting purposes and provided support for the Nation's manned orbital flights. The fifth satellite in the TIROS series was orbited in June, particularly to detect tropical storms of the fall hurricane season as well as to continue gathering other weather data.

Work continued on Nimbus, which is scheduled to succeed TIROS. Nimbus has instrumentation (TV cameras in daylight; IR sensors both day and night) which will receive data from the entire globe at least twice daily. Two data acquisition stations will allow worldwide coverage. A mockup prototype spacecraft was being assembled and components tested during this report period.

The period also witnessed progress in the development of communications satellites: Echo II underwent a vertical test to study inflation capability, a design study of a multilaunch spacecraft was continued, and work progressed on prototype Relay and Syncom active communications satellites. In addition, NASA cooperated with American Telephone & Telegraph Co. in making preparations to launch Telstar, another active (signal-transmitting) communications satellite.

From January through June 1962, research satellites, geoprobes, and sounding rockets contributed valuable data in astronomy and geophysics.

The first orbiting solar observatory (OSO–1) was launched on March 7 into a nearly circular orbit about 350 miles above the earth. It pointed very accurately at the center of the sun and made observations of the sun never possible before. Operating almost perfectly, OSO–1 observed and measured solar flares and subflares, examined particles in the lower Van Allen region, measured X- and gamma-radiation, and investigated dust particles in space. It transmitted about 1,000 hours of information on solar phenomena; the data were still being analyzed as the period ended. Preliminary analysis of the data, however, indicates that it contains new information on solar flares and quiet sun periods.

Another first was the launching of the United States-British Ariel—the first international ionosphere satellite—on April 26. Ariel contains six experiments prepared by British scientists to investigate the ionosphere and its relationships with the sun. Its instrumentation continued to transmit useful data through this report period.

A second geoprobe (the first was P–21) was used to make nighttime density studies of the ionosphere (a region 200 miles above the earth vital to radio communications). This geoprobe (P–21a) complemented the daytime investigations of P–21 launched in October 1961.

LAUNCH VEHICLES

To carry out its many space programs, NASA must employ reliable, high-performance launch vehicles. Accordingly, the Agency stressed the design and development of those needed for the future, continued to improve those now in use, and pressed for more powerful propulsion systems.

For the launch vehicles being developed, NASA made advances in design, testing, and fabrication. Titan II was selected to launch Gemini. It is being developed by the Air Force and during the period underwent two successful test firings.

Saturn C–1, the vehicle that will serve as the test bed for the Apollo program, underwent its second successful test firing. Work on the Saturn stages also progressed: The first stage for the third vehicle was static tested; that of the fourth vehicle was almost completely fabricated; and manufacture of the second stage S–IV is proceed-

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ing as programed to meet delivery date for its first live firing (with the fifth Saturn C-1 launch).

Advanced Saturn design and development work progressed as NASA accomplished several major preliminary steps: Signed a contract in February covering major aspects of the first stage; completed analysis for the structure of the second stage and the design phase of the third stage; and, through the contractor, began procuring material and fabricating the necessary tooling for the second stage.

The Centaur vehicle, which will have lunar, planetary, and earth orbital missions, consists of a liquid oxygen-liquid hydrogen upper stage (also called Centaur) with a modified Atlas first stage. On the first developmental flight in May, the Centaur stage exploded. The second flight has been delayed until necessary modifications can be incorporated in the vehicle.

For the Nova project, NASA reviewed the concept and preliminary design proposals, but delayed initiating contracts until it could determine the mode for the initial lunar landing mission.

To provide the power for these launch vehicles, NASA pushed development of advanced liquid propulsion engines. These include the RL-10 (A-1—15,000-pound-thrust—and A-3 versions), the J-2 (200,000-pound-thrust), and the M-1 (1.2-million-pound-thrust) hydrogen-oxygen engines; and the very large F-1 (1.5-million-pound-thrust) engine.

Along with emphasis on the development of large launch vehicles, NASA continued to seek improved performance and greater reliability from the launch vehicles already in use. A new third stage for Scout performed satisfactorily, and a higher thrust first stage and a new fourth stage were tested.

Delta continued in use as a launch vehicle for the TIROS and other satellites. Because of its proved reliability and effectiveness—nine consecutive successful launches—NASA increased the quantity to be procured and plans to use these for additional launches.

The Thor-Agena B and the Atlas-Agena B carried on as heavy-duty launch vehicles. Improvements were made in the Atlas-Agena B, before it successfully launched Ranger 4 and Mariner B. Because of the potential value of Agena B, NASA and the DOD agreed to develop a standardized advanced version—the Agena D.

PROPULSION AND POWER GENERATION RESEARCH

NASA continued to progress with numerous experiments and studies in propulsion and power generation. Liquid, solid, nuclear, and electric propulsion projects advanced knowledge and produced technology applying directly to both space flight and exploratory missions. Similarly, significant results stemmed from solar, chemical, and nuclear power generation research projects.

Liquid propulsion research efforts disclosed two promising concepts for thrust control of spacecraft engines; successfully demonstrated longtime storability and restartability of a spacecraft propulsion system; completed preliminary design of liquid rocket engines that produce 6 million or more pounds of thrust; and completed advanced design concepts of two extremely large engines (24-million-pound-thrust). Further, the Agency advanced its studies involving propellant flow, propellant flow measurement, and combustion chamber pressure measurement.

In conducting research on solid propulsion systems, NASA demonstrated a motor that uses multiple layers of propellants (one of the most efficient designs ever tested); moved toward development of a steering system to control the flight of solid propulsion vehicles; and completed a study of acoustical problems related to large solid motors (concluding generally that these problems pose no insurmountable obstacle for engineers). Additionally, the Agency continued investigating the potential of solids for large launch-vehicle stages.

In nuclear propulsion research, NASA continued its joint efforts with AEC to prove the Kiwi reactor design and to produce a nuclear rocket engine (NERVA). Also, the RIFT (Reactor In Flight Test) project advanced sufficiently to permit selection of a prime contractor to design, develop, test, and deliver a RIFT stage. Beyond RIFT, NASA took steps in June to advance the overall nuclear vehicle concept; this effort should lead to an operating vehicle for specific NASA missions.

Electric propulsion research activities also made headway. Three electrothermal (arc-jet) engine models were tested—one 1-kilowatt flight engine and two 30-kilowatt engines. Development work on two electrostatic (ion) engines continued; and NASA sponsored continued studies of electromagnetic (plasma) engines.

In its solar and chemical power-generation research endeavors, NASA extended studies related to solar cells, batteries, fuel cells, thermionic devices, mechanical power conversion, and solar concentrators. Studies to design a solar cell panel that would halve the number of cells needed per unit of power received increased attention. Under a battery-development program, NASA made available four standard-sized space batteries. It also neared complete development of a 250-watt hydrogen-oxygen fuel cell system and advanced the work on a regenerative hydrogen-oxygen fuel cell. Finally, it continued its efforts to develop the 3-kilowatt Sunflower turboelectric power system.

In nuclear power generation studies, NASA and AEC advanced the SNAP-8 (System for Nuclear Auxiliary Power) project. Further, NASA continued its work on the data and technology necessary to construct lightweight, high-powered nuclear electric systems. In this effort, it started test operations of two boiling and condensing potassium heat-transfer rigs—a 300-kilowatt loop and a 100-kilowatt test rig.

TRACKING NETWORKS

NASA expanded and improved the three networks—manned space flight, deep space, and satellite—that make up its worldwide communications and tracking system. It also improved the Wallops facility.

The manned space flight network performed effectively during the MA-6 and MA-7 flights. Nevertheless, NASA continued to improve this network by installing additional command and receiving equipment to strengthen the network's control and communications facilities.

Extensive improvements to the deep space network were in progress. The Goldstone, Calif., station acquired commercial electric power, an additional 85-foot parabolic antenna, and a 30-foot ranging antenna. The Johannesburg, Republic of South Africa, and Woomera, Australia, stations improved their capabilities to transmit commands to spacecraft.

Also, NASA continued to extend its satellite network; it progressed with the construction of a satellite tracking station in North Carolina and another in Alaska, and arranged to establish a third in the Far East.

NASA also installed equipment in the network's 13 operating stations so that they can handle more complex coding systems. And it began equipping them with antennas that will automatically track satellites.

The Wallops facility also improved its tracking facilities. It undertook to obtain a new amplifier that will greatly increase the tracking capabilities of its S-band radar. And it acquired a 940-ton ship to be used as a telemetry and surface surveillance station and a recovery vessel.

AERONAUTICS AND SPACE RESEARCH

The success of the Nation's long-range aeronautical and space endeavors depends directly on the research efforts now underway at NASA's centers and at the facilities of research contractors. These efforts produced significant results during the period covered by this report.

In the aeronautics field, the X–15 (NASA-Air Force-Navy) essentially reached its design altitude in a flight to 247,000 feet. Subsequently, it was decided to use the X–15 for research studies and experiments related to space flight. The Agency also extended its work on the kitelike paraglider—a device to enable space vehicles, capsules, and boosters to make "controlled" landings.

NASA continued to conduct research on many V/STOL (*V*ertical or *S*hort *T*akeoff and *L*anding) approaches and concepts, including tilt rotor, deflected slipstream, tilt wing, tilt duct, and fan-in-wing aircraft. Additionally, the Agency gained vital data on design and performance of supersonic transport aircraft, on handling requirements and qualities, and on aircraft structure. It also advanced its space research projects and broadened its base of knowledge for manned flight, unmanned exploration, scientific experiments, and navigation and guidance.

For stabilization and control of space vehicles and satellites, NASA experimented with adaptive and reaction controls (mechanical), with gyros, and with jet gas. It also determined instrument requirements for midcourse control.

Through other research activities geared to space missions, NASA progressed with its programs to provide astrophysical, biomedical, and engineering recording devices (for example, microminiaturized biological sensors and transmitters, freeing wearers of attached wires); took action leading to automated launch sites; began efforts related to improved data-processing systems and automatic computing devices; and furthered research to improve ways of transmitting sound and visual communications. The Agency also conducted experiments to solve the communication blackout problem during the critical reentry phase of space flight.

LIFE SCIENCE PROGRAMS

During this report period, NASA made substantial advances in the life science activities, which provide support for the Nation's space programs. In the orbital flights of Glenn and Carpenter, biomedical scientists demonstrated their ability to help assure the health, safety, and reliability of men in space flight missions.

Since the duration of weightlessness on these flights and the other stresses of space did not impair astronaut performance, an increasing number of orbits were being planned for later missions. Extended flights of two men in a single capsule (Project Gemini) and man's lunar travel and exploration (Project Apollo) thereby moved into clearer focus in the space timetable.

NASA further accelerated its life science activities by expanding its biosciences programs and by creating, in June, an Office of Biotechnology and Human Research in the Office of Advanced Research and Technology. Its purpose is to provide data on man's adaptability to outer space stresses as a basis for designing spacecraft of the future.

Research in biology was emphasized. Physical biologists intensified their efforts in planning and building more sophisticated instruments to measure life processses. Physiologists experimented with the growth and development of living matter in outer space environments simulated in the laboratory. They also continued to investigate the effects of weightlessness, radiation, and accelerations on the human body, and man's need for food and his other requirements in space.

Exobiologists analyzed meteorites for traces of life and sampled the earth's upper atmosphere for evidence of "seeding" of organic matter from planet to planet. They also planned instrumented spacecraft for Martian landings to identify living forms there in preparation for the eventual manned search of the moon and the planets for extraterrestrial life.

INTERNATIONAL COOPERATION

By June 30, 7 more Nations had joined the United States to support the development of peaceful uses of outer space, bringing to 57 those uniting with NASA in joint flights, flight support, or training programs.

Assistance from abroad ranged from creating the worldwide Mercury tracking network for the first manned orbital flight in February, to conducting special weather observations to aid in the research interpretations of TIROS data, and to plans for building terminals for this country's future communications satellites.

Over 50 scientists from 21 countries expressed an interest in becoming ground observers of signals from NASA's ionosphere beacon satellite, scheduled for launching early in 1963 to study the composition and behavior of the electrified levels of the atmosphere.

The Agency also enlisted the participation of the world's earth scientists in Project ANNA, which is to use a geodetic satellite to map the globe and study its gravitational field and internal composition.

During the reporting period 1,486 foreign nationals visited NASA facilities in the United States; NASA sent 145 of its personnel abroad to participate in international conferences and symposia. Seven students from 5 countries were studying the space sciences at 6 American universities, and 14 students from 3 countries received training in space research at Goddard Space Flight Center and Wallops Station.

MANAGEMENT, PROCUREMENT, SUPPORT, AND SERVICES

During this period, NASA added over 1,800 professional personnel to its staff. At the same time the Agency concentrated on training future executives to manage its varied, complex activities.

During this time, NASA's launch facilities at the Atlantic and Pacific Missile Ranges at Cape Canaveral, Fla., and Point Mugu, Calif., were set up as independent field installations for a more immediate response to the needs of specific flight programs.

Further, to improve its procurement management of the Apollo and S–II (second stage of advanced Saturn) programs, NASA placed an on-site management unit in the plant of a major contractor for direct administration of contracts.

To speed the availability of information generated by NASA-supported investigations and other data in space science and technology, NASA, in January, selected a contractor to operate its central scientific and technical information-processing facility.

In addition, the agency—seeking still more efficient, rapid methods of retrieving data by machines than those being used at this facility—signed a research contract emphasizing information and data retrieval.

As this report is being prepared, NASA continues to make significant advances. The experimental communications satellite Telstar was launched on July 10; it successfully relayed intercontinental telephone, radio, and television messages. Mariner II, placed on a Venus fly-by trajectory on August 27, initially followed an off-course path but was effectively corrected by radio signal on September 4. Calculated miss distance was 20,000 statute miles, well within the allowable 40,000-mile effective range. On October 3, a completely successful six-orbit manned flight took place, with Astronaut Walter M. Schirra as pilot of the spacecraft Sigma 7.

Major NASA Launchings, Cape Canaveral, Fla., Jan. 1–Oct. 31, 1962

Name, date launched, mission	Launch vehicle	Test results
Ranger III, Jan. 26. To impact moon; TV photography and X-ray spectroscopy; rough-land survivable capsule containing seismometer; perform engineering experiments in attitude control and guidance.	Atlas-Agena B	Moon not impacted; placed in solar orbit. TV signal too weak to be useful. Gamma-ray data received.
TIROS IV, Feb. 8. To help develop a weather satellite system; obtain cloud and radiation data for use in meteorology.	Delta	Orbit achieved. All systems transmitting data. Transmission of useful TV pictures ended about June 12.
Mercury-Atlas VI, Feb. 20. To orbit and recover manned spacecraft; evaluate spacecraft performance; investigate man's capabilities in space environment; obtain pilot's evaluation of operational suitability of spacecraft and supporting systems.	Atlas D	Orbit achieved; spacecraft and astronaut recovered.
Orbiting Solar Observatory (OSO–I), Mar. 7. To place satellite in earth orbit to measure solar electromagnetic radiation in the ultraviolet, X-ray and gamma ray regions; investigate dust particles in space and improve future spacecraft design.	Delta	Orbit achieved. Experiments transmitting as programed.
Ranger IV, Apr. 23. To impact moon; TV photography and X-ray spectroscopy of lunar surface; rough-land survivable seismometer on lunar surface; perform engineering experiments in attitude control and guidance.	Atlas-Agena B	Impacted moon. No scientific data obtained.
Ariel (first international ionosphere satellite, United States-British S–51), Apr. 26. To place satellite in earth orbit and to investigate the ionosphere and its relationship with the sun.	Delta	Orbit achieved. Most experiments transmitting data.
Mercury-Atlas VII, May 24. To orbit and recover manned spacecraft to: evaluate man-spacecraft system performance; investigate man's capabilities in space; obtain pilot's opinion on spacecraft and allied systems suitability.	Atlas D	Orbit and all other objectives achieved. Spacecraft and pilot recovered.
TIROS V, June 19. To place satellite in earth orbit to: provide weather data for operational weather analysis and research study, especially during the 1962 hurricane season; develop principles toward operational weather satellite system.	Delta	Orbit achieved. Cameras transmitting excellent photographs.

The following launchings occurred after the closing date of this report:

Telstar I—July 10, 1962
Mariner II—Aug. 27, 1962
TIROS VI—Sept. 18, 1962
Explorer XIV—Oct. 2, 1962
Mercury-Atlas VIII—Oct. 3, 1962
Ranger V—Oct. 18, 1962
Explorer XV—Oct. 27, 1962
ANNA—Oct. 31, 1962

NOTE.—Information outlined in this table is given in greater detail in the Space Activities Summaries prepared by and available from the Office of Public Services and Information, National Aeronautics and Space Administration, Washington 25, D.C.

Activities and Accomplishments—

The Details

CHAPTER 1

Large Launch Vehicle and Manned Spacecraft Development

During this reporting period, NASA made significant progress toward developing large launch vehicles, together with bigger engines, and manned spacecraft. Accomplishments in these areas reflect the dual emphasis placed on the short-range goal of a lunar landing during this decade and the long-range objective of preeminence in space.

LAUNCH VEHICLES BEING DEVELOPED

NASA took vigorous steps to develop and make way for production of the more powerful launch vehicles that are necessary for the Gemini and Apollo projects, as well as for certain unmanned space programs. These vehicles include the Saturn C-1, the Advanced Saturn C-5, the Titan II, the Centaur, and the Nova concept.

Saturn C-1

The Saturn C-1, designed to launch heavy payloads in the period beyond 1963, will be the test bed for the Apollo spacecraft program. The first stage of this vehicle consists of eight H-1 engines clustered; its takeoff thrust is 1.5 million pounds.

NASA has conducted two successful flights of the C-1. The first was discussed in NASA's sixth semiannual report; the second, illustrated in figure 1-1, took place on April 25. In both tests, the vehicle consisted of the live first stage and dummy second and third stages. NASA designated the first vehicle SA-1; the second, SA-2.

The SA-2 vehicle arrived at Cape Canaveral via barge on February 27, 1962, and was erected on the launch pad on March 2. When the 10-hour countdown began (April 24), it proceeded without a single technical problem. A ship entering the range area caused the sole delay. Overall vehicle performance was completely satisfactory. Only the long cable mast and the LOX mast suffered real damage from the launch; other components suffered only minor damage. Erection of the umbilical tower will eliminate the long masts for future flights.

In addition to having a successful launch, the SA-2 enabled NASA to conduct Project High Water. The vehicle carried 95 tons of water

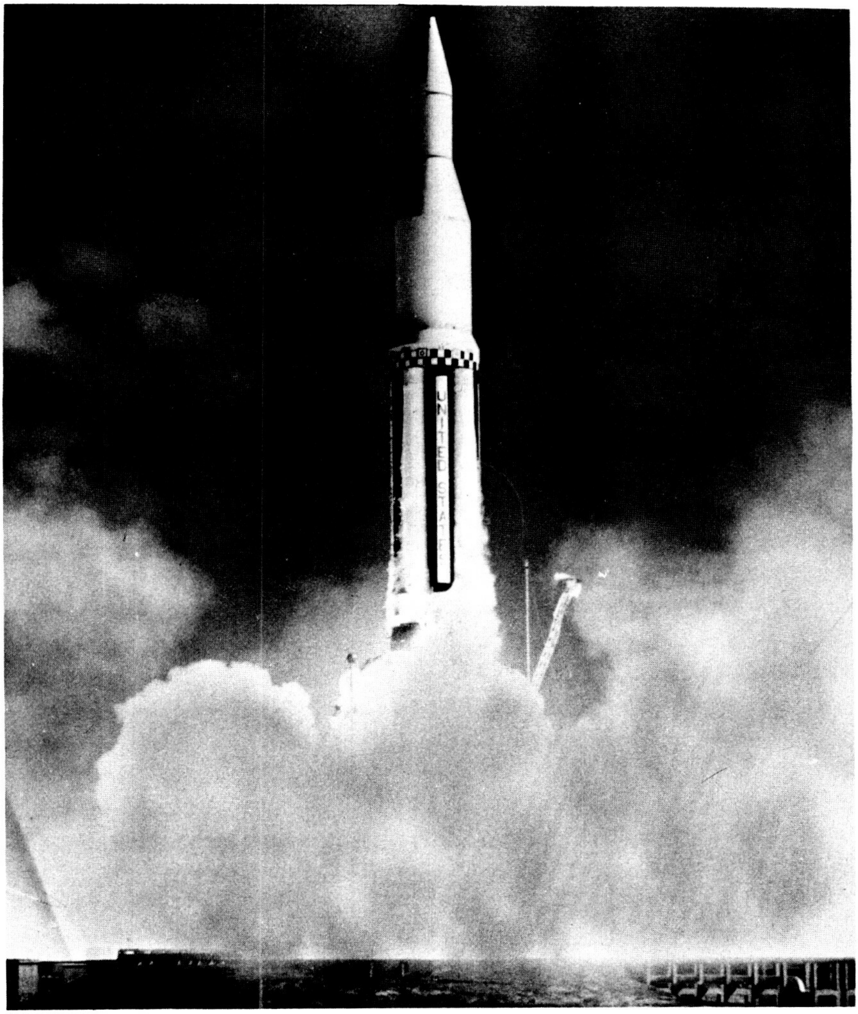

Figure 1–1. Second test flight of Saturn C–1.

ballast and dumped it at an altitude of 65 miles. This experiment provided scientists with the information discussed in chapter 3, page 50.

Following the first four flight tests (SA–1 through SA–4), the SA–5 and SA–6 launches will provide orbital flight tests of the boiler-plate Apollo A spacecraft. Flights SA–7 and SA–8 will provide re-entry tests on the spacecraft. And launches SA–9 and SA–10 will provide flight tests for the Apollo prototype spacecraft. Assuming successful completion of these tests, subsequent vehicles will be considered operational.

Progress With S–1 First Stage.—Work on the S–I stage of the third Saturn flight (SA–3) is proceeding on schedule; the stage has been static fired for a short duration. NASA expects to launch the SA–3 in the fall of 1962.

Work on the S–I for the fourth flight is also on schedule—structural fabrication is almost complete, and final assembly is in the last stage. All eight of its H–1 engines were successfully tested and approved for installation.

For test firings after the fourth (SA–4), the S–I stage will have a different configuration. Redesign of this vehicle for test flight No. 5 (SA–5) is progressing on schedule. Figure 1–2 illustrates the configurations of the Saturn C–1 for the first four flights and that for flights from SA–5 on.

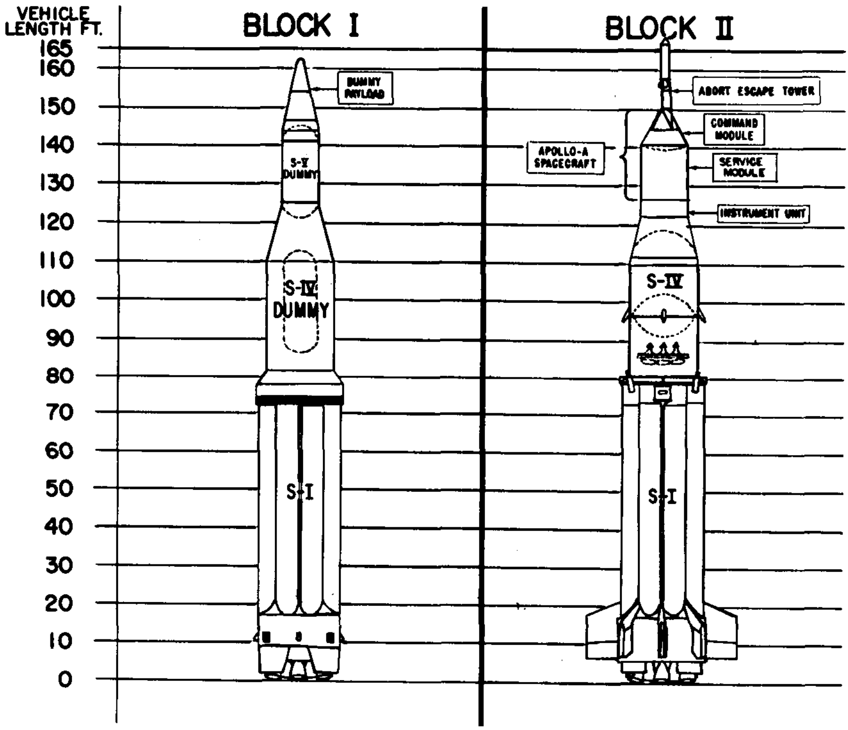

Figure 1–2. Development vehicle configurations.

Besides having a new S–I configuration, SA–5 will have a powered S–IV second stage.

Progress With the Second Stage (S–IV).—The S–IV (second) stage of the Saturn C–1 vehicle consists of six RL10 A–3 liquid oxygen-liquid hydrogen engines, each of which generates a thrust of 15,000 pounds for a total thrust of 90,000 pounds. The S–IV will have its first powered flight on the fifth Saturn launch (SA–5).

The contractor's S–IV static test facility stand No. 1, at Sacramento, Calif., was modified and the static test vehicle installed. Hot firings of all six engines then took place.

The S–IV manufacturing plan is proceeding as programed and should meet the delivery date for the SA–5.

Advanced Saturn

The Advanced Saturn launch vehicle will serve as a basic vehicle for manned circumlunar missions (flights from earth around the far side of the moon and back to earth), for lunar orbital missions (Apollo), and for supporting unmanned lunar and planetary explorations. This launch vehicle, shown in fig. 1–3, will be able to put more than 100 tons in a low earth orbit or to send more than 40 tons to the vicinity of the moon.

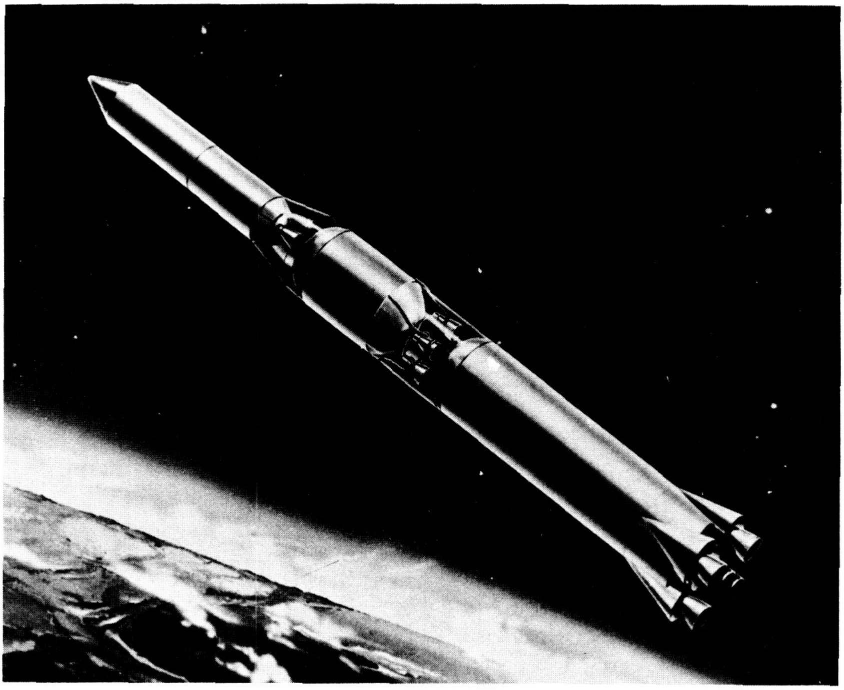

Figure 1–3. Sketch of Advanced Saturn highlights S–II stage.

NASA announced on April 18, 1962, that the highest national priority (DX) had been approved for Apollo, Saturn C–1, and Saturn C–5. The priority includes all stages, engines, facilities, and related construction for production, test, research, launch and instrumentation.

Booster Stage (S–IC).—The Advanced Saturn first or booster stage (S–IC) will be powered by five F–1 engines for a total thrust of 7.5 million pounds. It will have a propellant capacity of approximately 4.4 million pounds of liquid oxygen and kerosene carried in two tanks, each 33 feet in diameter.

In late 1961, NASA held a design competition for the S–IC stage. On February 14, 1962, the agency signed a preliminary contract (with a performance period through July 31, 1962), covering indoctrination, planning, design, development, manufacture, test, and launch operations of S–IC stages.

Second Stage (S–II).—The second stage (S–II) will be powered by five J–2 engines, each developing 200,000 pounds of thrust. The propellant (liquid oxygen and liquid hydrogen) capacity will be about 930,000 pounds. (Fig. 1–4 shows a cutaway of this stage.)

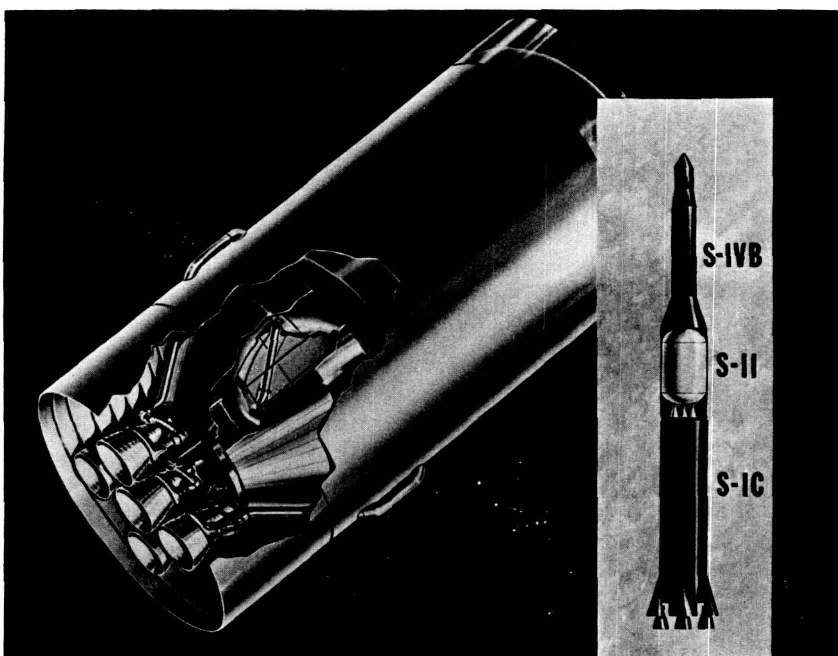

Figure 1–4. Cutaway of S–II stage and an Advanced Saturn configuration.

For various components of the system, the development contractor has completed preliminary analyses of the stage structure; studied, evaluated, defined, and coordinated design concepts and efforts; prepared specifications and drawings; and started action to procure material and to fabricate tooling.

Third Stage (S–IVB).—The third stage (S–IVB) of the Advanced Saturn, shown in figure 1–5, will use one J–2 engine for a total thrust of 200,000 pounds. It will carry 230,000 pounds of liquid oxygen-liquid hydrogen propellant. The preliminary design phase was completed during this period. This phase included a complete program for design, development, manufacture, and operational support of the S–IVB stage, including checkout and support equipment. The program is making use of S–IV (Saturn C–1 second stage) technology and design philosophy; it will also use S–IV parts and tooling.

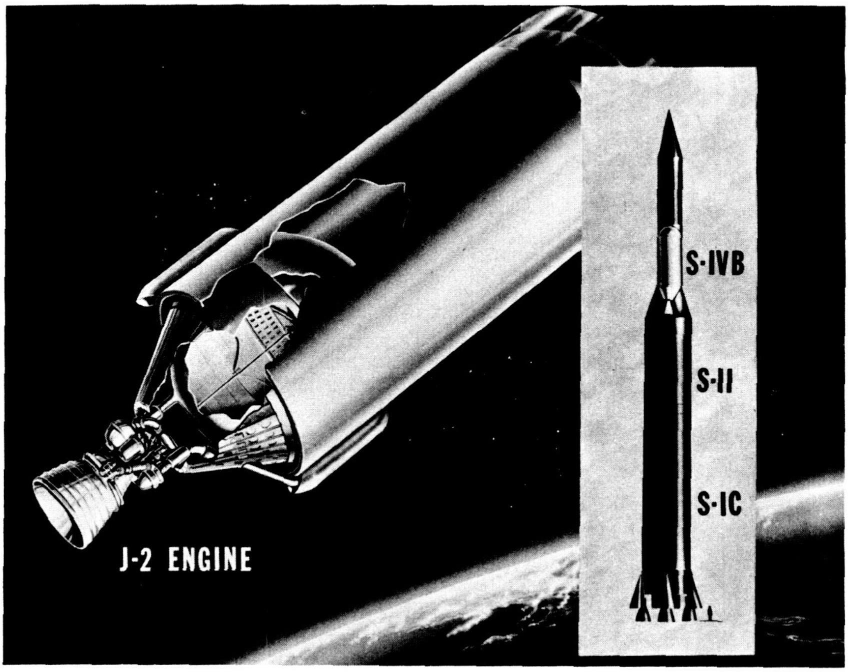

Figure 1–5. Cutaway of S–IVB stage.

Titan II

NASA had already selected the Air Force-developed Titan II as the launch vehicle for the Gemini spacecraft. The agency made this selection to save both the money and the time that a new development program for an equally powerful vehicle would require.

During January and February, this vehicle underwent additional captive firing tests. On March 16, the Air Force successfully fired a Titan II; on this first full-scale test, the vehicle flew 5,000 miles out over the Atlantic Ocean. A second successful test launch by the Air Force occurred on June 7. The program calls for additional flight tests of Titan II during the next report period.

During this period, NASA worked closely with the Air Force and the contractor to modify the Titan II for manned space flight.

Atlas-Centaur

The Atlas-Centaur, the two-stage vehicle using the Atlas first stage and a new liquid oxygen-liquid hydrogen engine second stage, has missions in support of lunar and planetary programs such as the Surveyor and the advanced Mariner B.

The first Atlas-Centaur, illustrated in figure 1–6, was launched from Cape Canaveral on May 8, 1962. After 54 seconds of flight, the Centaur stage exploded. The Atlas booster performed well until the explosion occurred. It was concluded that aerodynamic forces lifted the weather shield between the forward end of the vehicle and the nose cone, causing the failure. This part will be redesigned and tested before a second test flight—now scheduled for early 1963.

Despite the failure, NASA derived benefits: It accomplished the objectives of successfully testing the launch facility and mating the vehicle to it. Personnel also gained confidence in their ability to handle the extremely cold liquid hydrogen.

Nova

The Nova launch vehicle, illustrated in figure 1–7, represents the next proposed step up the higher thrust, greater payload-capacity scale. During the reporting period, NASA reviewed proposals for a detailed system definition and preliminary design of this vehicle. (The Nova concept was discussed in detail in NASA's sixth semiannual report.)

NASA delayed initiating contracts until a decision was reached on the primary method of lunar landing. (Since the end of the reporting period, NASA selected the lunar orbital rendezvous technique and immediately began a reoriented study of the Nova configuration.)

LIQUID PROPULSION ENGINES BEING DEVELOPED

Launch vehicle development directly affects the pace at which NASA can progress toward its many goals. In turn, engine development determines the rate of progress of the advanced launch vehicle programs. Achievements in the individual engine projects have a significant bearing on the Nation's overall space effort. NASA is pressing for operational capability of the four liquid propellant en-

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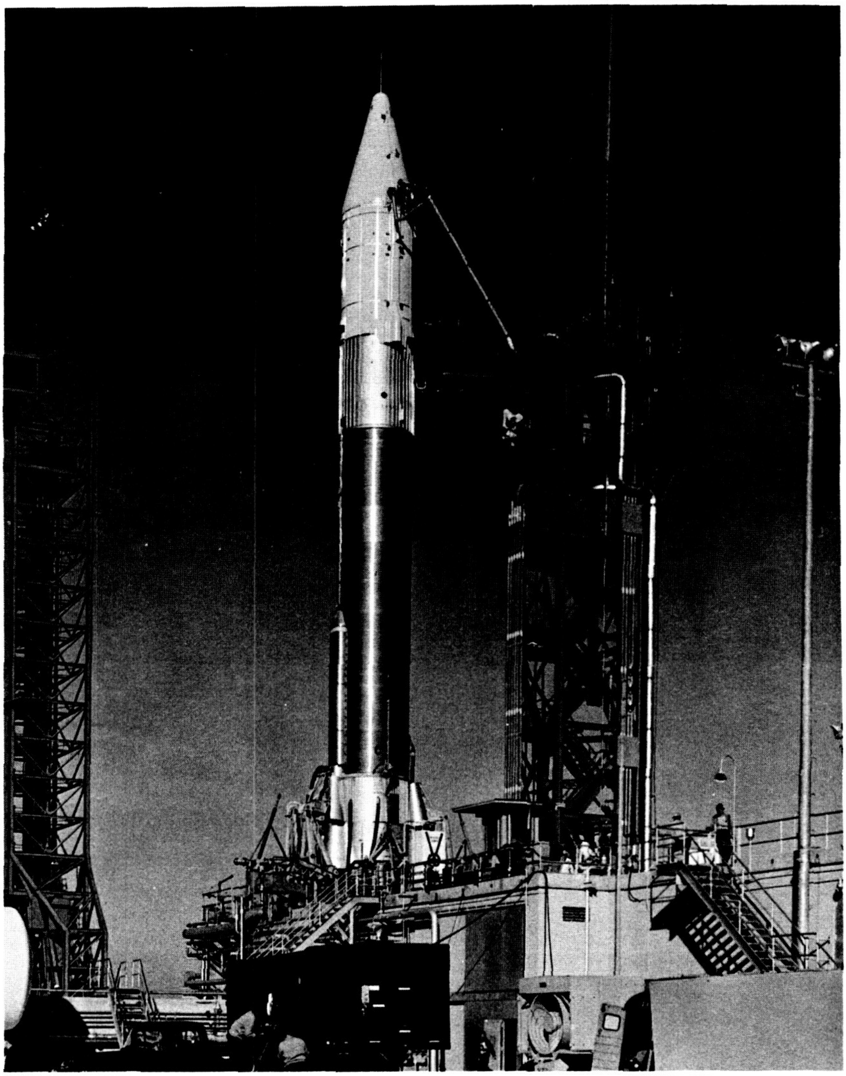

Figure 1–6. Centaur atop an Atlas D booster.

gines needed in the immediate future. These are designated the RL–10, the J–2, the M–1, and the F–1.

The RL–10 Rocket Engine

The RL–10 is the Nation's first rocket engine developed to use hydrogen as a fuel. It uses liquid hydrogen and liquid oxygen propellants, develops a thrust of 15,000 pounds, and is about 35 percent more effective than rocket engines fueled with kerosene.

An early version of the engine, designated A–1, qualified for limited use in experimental flight programs toward the end of 1961 and is now in production. NASA will use it in the present two-engined Centaur vehicle and in ground testing related to Saturn's six-engined S–IV stage.

An advanced version of the engine, designated A–3, will be used in later versions of the Centaur vehicle and in the S–IV flight stage.

Development work on the A–3 engine has progressed far enough to permit the test which qualifies the engine for experimental flight operations. This development work has produced improvements in several areas where the A–1 engine was deficient. Among these are thrust control during engine startup and shutdown and a simplified method of achieving propellant flow balance. In addition, the A–3 engine will have increased performance over the A–1.

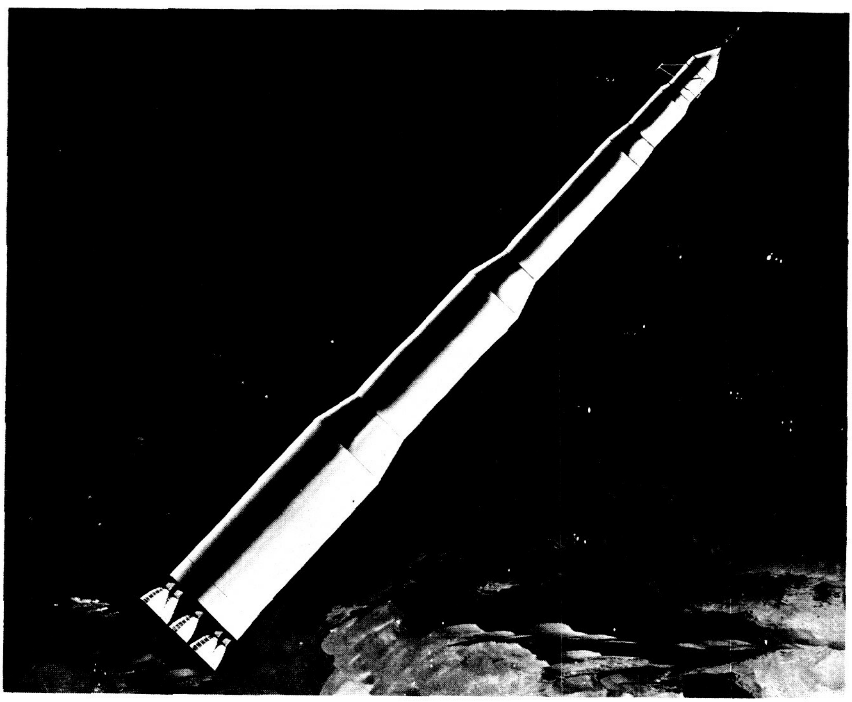

Figure 1–7. Artist's concept of the Nova vehicle.

J–2 Hydrogen-Oxygen Engine

The J–2 hydrogen-oxygen engine will provide the power for both the second and third stages of the advanced Saturn. Tests of the engine's major components proceeded to a point that permitted assembly into a complete engine. The first J–2 engine underwent a series of cold tests in which mechanical components were activated and propellants flowed but were not ignited. This test checked the operation of the system involved in starting the engine.

The first J–2 engine was hot-tested at the end of March. In the following weeks, this same engine was operated about a dozen times and attained a thrust (calculated for vacuum conditions) of over 200,000 pounds. Initial problems included failure of the hydrogen pump to maintain a continuous flow to the engine, and overheating of gas generator. Subsequent tests have attempted to correct these difficulties and attain longer runs.

The M–1 Engine

The M–1, largest of the hydrogen-oxygen engines being developed, will power the upper stages of the large launch vehicles such as Nova. It will produce 1.2 million pounds of thrust.

In January, after competitive negotiations, NASA selected a contractor to design and develop the M–1 and confirmed the selection by signing a letter contract on April 30. Design and development are now proceeding on schedule.

The F–1 Engine

The F–1 engine is intended for use in the first stage of the advanced Saturn. The planned cluster of five F–1's will give the first stage of the advanced Saturn a total thrust of 7.5 million pounds.

In tests, the F–1 ran for 150 seconds at less than rated thrust; only for shorter periods did it produce the full 1.5 million pounds. The rate of testing was deliberately held down to permit careful inspection of the running parts. There was additional delay because one of the two test stands was inoperative for 2 months.

The F–1 program made satisfactory progress in other areas. These include development of the gas generator that drives the pump, redesign of this generator's injector, and assembly and fabrication of a satisfactory thrust chamber structure.

F–1 deliveries should start in mid-1963 to meet advanced Saturn requirements. For this reason, test stand construction has increased. NASA let a contract to design a facility of three acceptance test stands and support activities to be built at Edwards Air Force Base. Excavation has already started; construction was to begin in the fall of 1962, with completion of the first stand expected 1 year later.

Overall, NASA continued its drive to update, develop, and produce the launch vehicles for all of its planned programs. Early achievements of such operational systems is vital to the Nation's total space effort. Based on the progress as identified here, this Agency is confident that it can accomplish the launchings scheduled—and can do so within the time periods selected.

MANNED SPACECRAFT DEVELOPMENT

While NASA's large launch-vehicle engine development programs were being pushed, the manned space flight and spacecraft programs achieved historic goals in certain areas and made notable progress in others.

Project Mercury reached its second milestone in the advance from short-time manned suborbital flight toward an orbital mission of 24 hours. Project Gemini continued its progress as the follow-on to Mercury. And Apollo moved forward to the point that it became feasible to intensify design and development of the spacecraft command and service modules.

Project Mercury

Twice during the period Project Mercury achieved manned orbital flight. In the first instance, Astronaut John H. Glenn, Jr., was at the controls of the Friendship 7 spacecraft. In the second flight, Astronaut Malcolm Scott Carpenter performed the control tasks. Data acquired from these flights enabled NASA to plan the progressively longer orbital missions of the Mercury project through the "one-day mission."

First Manned Orbital Flight.—The first manned orbital flight of Project Mercury took place on February 20, 1962. (See fig. 1–8.) The major objectives were to investigate man's capabilities in the space environment and to test both spacecraft and supporting systems. The flight met all test objectives and was therefore completely successful.

Lift-off, launch, and insertion into orbit were perfect. The apogee of orbit was about 141 miles; perigee was about 86. The actual sequence, flight, and tracking times were all within seconds of those planned.

The flight accomplished three full orbits before the spacecraft landed in the planned recovery area, 700 miles southeast of Cape Canaveral, at 2:43 p.m. e.s.t. During this flight, Glenn experienced weightlessness for 4.6 hours with no adverse effect on his performance. He reported it to be a rather pleasant sensation.

The astronaut made visual and photographic observations of the earth, clouds, horizon, and stars. He also observed brilliant luminous particles ("fireflies") traveling with him in orbit at every sunrise (an observation confirmed by Carpenter in the next orbital flight).

The source and nature of these particles are under intensive scientific study, but they remain unidentified.

The Operations Director was faced with a critical decision during the flight. A telemetry signal indicated that the landing bag and heat shield were deployed while the spacecraft was in orbit. Ground system monitors could not determine whether the heat shield deployment mechanism had been actuated or a sensing switch failure was producing a false telemetry signal. Therefore, Glenn received instructions to reenter with the retropackage still held fast to the heat shield. The straps which retain the retropackage would thus give added assurance that the heat shield would not separate prematurely. Reentry occurred without incident, and subsequent investigation showed a malfunctioning switch in the indication circuit.

Figure 1–8. Astronaut Glenn boarding Friendship 7 spacecraft.

The capsule landed 5 miles from the destroyer U.S.S. *Noa* and was quickly recovered from the water in good condition.

Second Manned Orbital Flight (*MA–7*).—The second orbital flight of the Project Mercury program took place on May 24, 1962, with Astronaut Malcolm Scott Carpenter in the spacecraft Aurora 7. The objective of this flight was to continue the evaluation of man's capabilities in the space environment. The flight was successful and yielded a great quantity of useful engineering and scientific data.

Lift-off (shown in figure 1–9) took place at 7:45 a.m. e.s.t. from Cape Canaveral. The launching was particularly notable, for it occurred without a single hold for the launch vehicle or spacecraft systems. The entire powered phase of flight was normal, and all systems functioned perfectly. Apogee and perigee of the orbit were about 145 and 86 miles, respectively, and all times and operations were nominal. After three full orbits, the spacecraft landed at 12:31 p.m. e.s.t., 250 miles downrange of the planned recovery area.

As was the case with Glenn in the MA–6 flight, Carpenter experienced about 5 hours of weightlessness. He reported that it was the first time his pressure suit had ever felt comfortable.

In addition to making visual observations, he took over 200 color shots of clouds, terrain, sunset, the booster, and the sunrise particles or "fireflies" that Glenn had reported. These photographs will be of great value in developing space navigational procedures, in making meteorological studies, in detecting meteorite impact features on earth, and in studying light characteristics in the upper atmosphere.

Carpenter made observations of the "haze" layer, using the window reticle and special light filters. He also performed tests to determine how best to visually orient the spacecraft while on the dark side of the orbit.

Additional experiments conducted during the flight included recording the motions of an enclosed liquid under conditions of weightlessness, tracking the booster in orbit from the spacecraft, and observing a balloon tethered to the orbiting spacecraft. The last experiment, designed to make drag measurements and determine the astronaut's color-sighting ability, was not successful.

The MA–7 flight proceeded smoothly with only minor technical difficulties until the end of the third orbit over Hawaii, just prior to retrofire. At that time, Carpenter reported difficulty with the automatic control system which established the spacecraft attitude for retrofire. To meet the emergency, the astronaut manually controlled retrofire and the spacecraft attitude. Variations between desired and actual spacecraft attitude and time of firing resulted in an overshoot of the planned recovery area by 200–250 miles.

Astronaut Carpenter was sighted by a search plane about 1 hour after impact. Three hours after he landed, helicopters from the U.S.S. *Intrepid* picked him up. The spacecraft was recovered by the destroyer U.S.S. *Pierce*, approximately 6 hours after impact.

Mission Planning for Future Mercury Flights.—The next U.S. manned orbital flight is scheduled for late 1962; the program calls

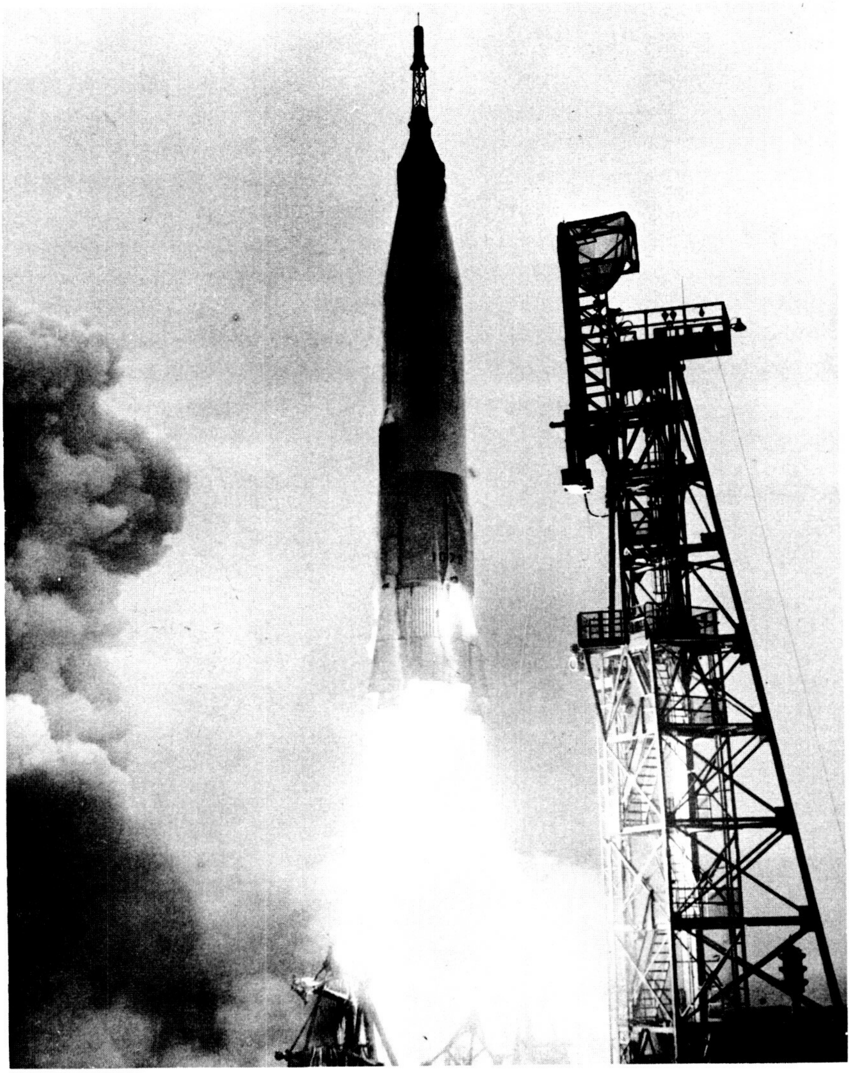

Figure 1–9. Liftoff—Astronaut Carpenter inside Aurcra 7 atop Atlas booster.

for as many as six orbits. No major change in spacecraft systems will be required, but the flight plan anticipates considerable "drifting" flight to conserve fuel for reentry maneuvering. An evaluation of the results of this flight will determine whether NASA will need an additional Mercury flight of this duration. Following this flight will come the "1-day mission."

The 1-day mission represents an extension of the Mercury program in that it will use existing hardware in flights of 24 hours. Such a mission provides the opportunity to acquire essential data on human reaction to an extended period of weightlessness and also serves to better evaluate spacecraft systems and the Mercury network. The knowledge gained from the completion of this program will be directly applicable to NASA manned space flight projects such as Gemini and Apollo.

Four Mercury spacecraft will be modified for the 1-day missions. Modifications to the present Mercury configuration will increase the quantity of life-supporting consumables such as oxygen, food, and water; also, certain equipment changes will be made as an outgrowth of Mercury experience. Work on modifying and assembling the spacecraft is proceeding on schedule.

The flight plan for the 1-day mission will provide for conservation and best use of other consumables such as attitude control fuel and electrical power. The spacecraft will be launched from Cape Canaveral, using the Atlas launch vehicle. After launch, the spacecraft will orbit the earth for up to 24 hours, then reenter and land in a predetermined area of the Atlantic Ocean. The tracking and data-acquisition facilities of the existing Mercury network will be extended to support the 1-day mission.

Project Orbit, the mission simulation portion of the 1-day mission project, is of particular interest. Here a complete production spacecraft is "flown" in the simulated vacuum and temperature of an earth-orbit for any length of time desired. The spacecraft systems are operated as they would be on an actual 1-day mission and extensive data are collected. The mission simulation is designed to test particular subsystems and to establish a high level of confidence in systems performance. The testing to date has materially helped to fix and confirm the new design of a thruster for controlling the spacecraft attitude and to establish reliable quantity figures for consumables during a 1-day mission.

Plans call for the first manned 1-day mission early in 1963. The accomplishments and timing of the remaining missions will lead logically and expeditiously into the Gemini program.

Project Gemini

Project Gemini will provide a two-man spacecraft to develop the orbital rendezvous technique (shown in fig. 1–10), and to study the effects of weightlessness during space flights of long duration. Such a spacecraft will be capable of performing a variety of missions. For instance, its ability to carry out orbital rendezvous might allow it to be used as a vehicle for resupply, spacecraft inspection or repair, orbital rescue, or personnel transfer.

The Gemini Concept.—In general, the Gemini project philosophy is to make maximum use of available hardware developed for other programs but modified to meet the needs of this project. In this way, NASA minimizes requirements for hardware development and qualification and makes certain that the project will proceed rapidly.

Another fundamental concept is that the design of the spacecraft will provide for modular systems independent of each other as much as possible. Consequently, NASA can use equipment of varying degrees of sophistication as it becomes available and as mission requirements are tightened. It can thus attain mission objectives as rapidly as the state of the art permits.

Gemini resembles the present Mercury vehicle and makes use of its proven basic concepts, retaining the aerodynamic shape, thermal protection, and systems hardware. However, Gemini is larger (as shown in fig. 1–11): it will accommodate a crew of two; it will have

Figure 1–10. Gemini spacecraft approaches rendezvous with Agena B (sketch).

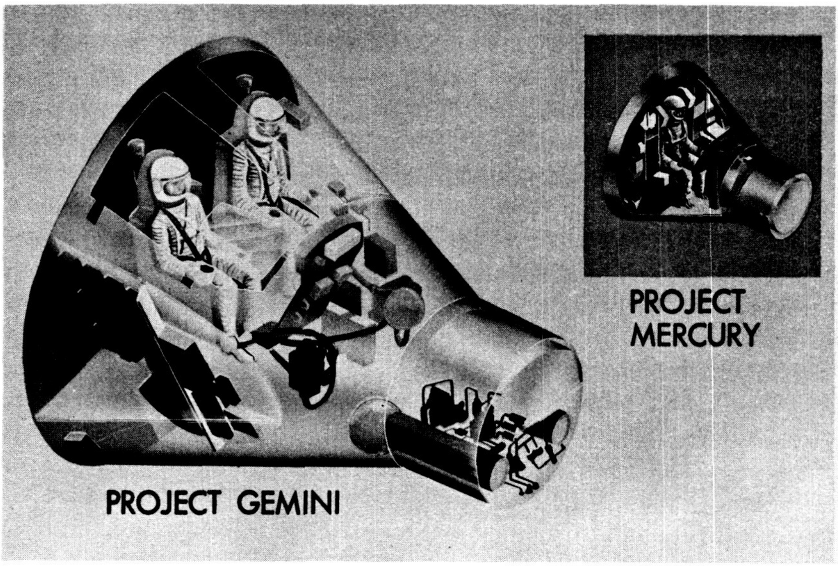

Figure 1–11. Comparison of Gemini and Mercury spacecraft.

ejection seats for pad emergencies and for a backup recovery system; structural and equipment rearrangements will provide for improved access; and a portion of the adapter will be retained in orbit to house certain expendable equipment.

The spacecraft booster will be the Titan II, modified as required for use as a man-rated launch vehicle. Such modifications will enable the Titan to accept the Gemini spacecraft as a payload and assure pilot safety during the launch operation. Additional changes will increase the probability of mission success. Titan II and all supporting equipment will be used to the maximum to conserve time and effort in the development of the launch vehicle.

The target for the rendezvous missions will be the Agena vehicle, suitably modified to provide multiple restart, radar and visual acquisition, reception, and docking. An Atlas D launch vehicle will place the Agena target in orbit. All presently planned launches will be from the Atlantic Missile Range.

Progress and Schedule.—Since the Gemini project began, NASA has let letter contracts for the spacecraft, the Titan II launch vehicle, and the Agena. Work is also in process on major subsystems, either by associate or subcontractor arrangements.

At present, NASA plans 12 spacecraft and 8 target launches. The schedule calls for initial manned spacecraft launches during the last half of 1963 and target rendezvous missions during 1964 and 1965. Such a schedule provides the logical transition into the Apollo program.

Project Apollo

The objective of Project Apollo is to land men on the moon and return them to earth within the present decade. The techniques, methods, and equipment involved represent a cumulative outgrowth of experience and knowledge acquired from Mercury, Gemini, and the other research programs of NASA.

Lunar Landing Mode Possibilities Studied.—During the first half of 1962, detailed comparative studies of several mission modes for implementing the manned lunar program were underway. The studies reviewed three techniques (illustrated in fig. 1–12): direct ascent, earth orbit rendezvous, and lunar orbital rendezvous.

In studying the mode to be selected, NASA officials are applying the following criteria: The mode must permit early mission accomplishment with an acceptable mission risk; it must have no requirements for technological breakthrough; it must provide for growth potential beyond the first manned lunar landing; and its total cost must be reasonable. The NASA centers and several industrial

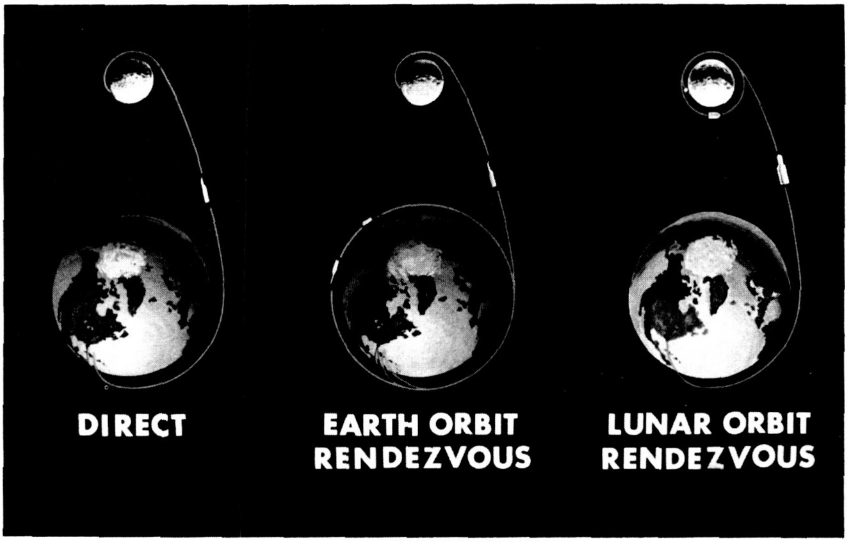

Figure 1–12. Possible flight techniques for Project Apollo.

contractors are participating in these studies. They expect to complete the analyses by mid-1962 and recommend the most feasible mode shortly thereafter.[1] NASA will then initiate development of the lunar landing module or its equivalent—the only major spacecraft

[1] The choice of the lunar orbital rendezvous technique for the Apollo mission was announced just after the close of this reporting period.

component not yet contracted for. Plans call for letting this development contract during the latter part of 1962.

Apollo Spacecraft Design and Development Underway.—The Apollo spacecraft command and service modules (illustrated in fig. 1–13) are now being designed and developed by the previously selected contractor. In addition to developing these modules, this contractor will also integrate the complete spacecraft.

NASA and its contractor associates have formulated engineering and development test plans, such as those for wind-tunnel tests, and many such tests are underway. A total wind-tunnel program of over 8,000 hours is planned for 1962.

Major ground and flight tests are also being planned. These include earth-impact drops, flotation and egress trials, structural and systems tests, thermal tests, vacuum leakage tests, and radiofrequency compatibility and antenna pattern tests. (Other plans call for development, manufacture, maintenance, and support of test facilities.)

NASA has selected contractors to design and build a number of the major subsystems of the Apollo spacecraft. These subsystems include

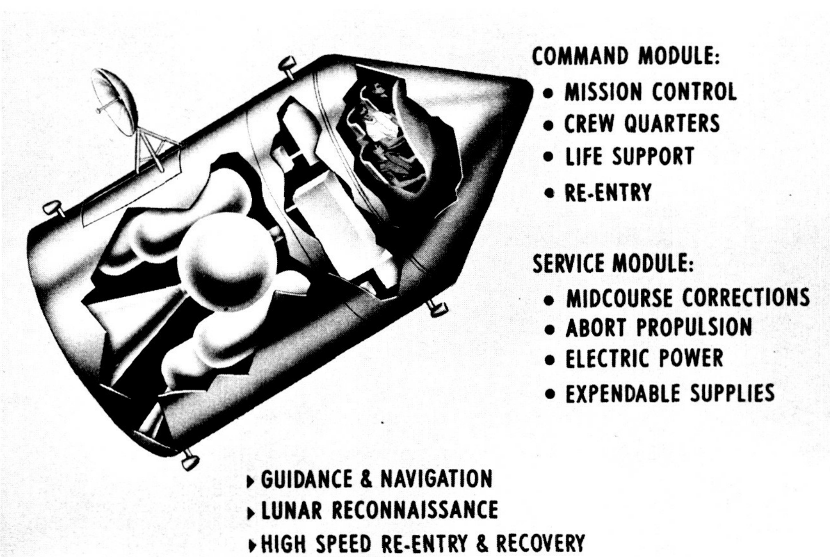

Figure 1–13. Apollo spacecraft circumlunar configuration.

the telecommunication system, the stabilization and control system, the environmental control system, the parachute landing system, the service module propulsion engine, the launch-escape motor (to separate the command module from the launch vehicle in case of abort), the solid-propellant tower jettison motor, the heat shield, the reaction control system, and the fuel cell prime electrical power source. Also, NASA is working with an associate contractor to develop the critically important guidance and navigation system. NASA has selected a contractor to assist in the checkout, reliability, and integration of all elements essential to the success of the complex.

Apollo Flight Test Program.—The first Apollo flight tests will be simulated pad aborts, using boilerplate construction test spacecraft. These will evaluate the launch-escape system performance for pad emergency escape. For these tests, only the solid propellant launch-escape rocket will be fired.

Next, NASA will test the Apollo launch-escape system under actual full-scale flight conditions of maximum aerodynamic loading; for these, NASA will use a large clustered solid-propellant launch vehicle, developed specifically for the Apollo program. This launch vehicle will be able to accelerate the Apollo command module to the same peak aerodynamic loading that will occur in later Saturn flights.

Concurrent with the launch-escape system tests, NASA will conduct the first test flights of the boilerplate Apollo spacecraft on Saturn launch vehicles. (See fig. 1–14.) The first two flights, planned for 1963, will be orbital missions but without spacecraft recovery. These tests will evaluate launch vehicle development and determine spacecraft-launch vehicle interaction.

In connection with the test program, NASA awarded a contract for engineering studies and design criteria for space environment simulation chambers. This contract covers studies of vacuum chamber design concepts, their costs, preparation of study reports, and design layouts of the facilities.

The largest chamber will accommodate a complete space vehicle 75 feet high and at least 25 feet in inner working diameter. This chamber will be able to simulate a vacuum environment equivalent to that at 80 miles altitude and will provide temperatures expected on the moon's surface. It will also simulate solar radiation in space.

Overall, the manned space flight program is moving at an accelerated pace, according to a logical schedule. Despite the complex technological problems to be overcome, there is every expectation that Project Apollo will place men on the moon and return them to earth within this decade. NASA is making every effort to achieve this high-priority national goal.

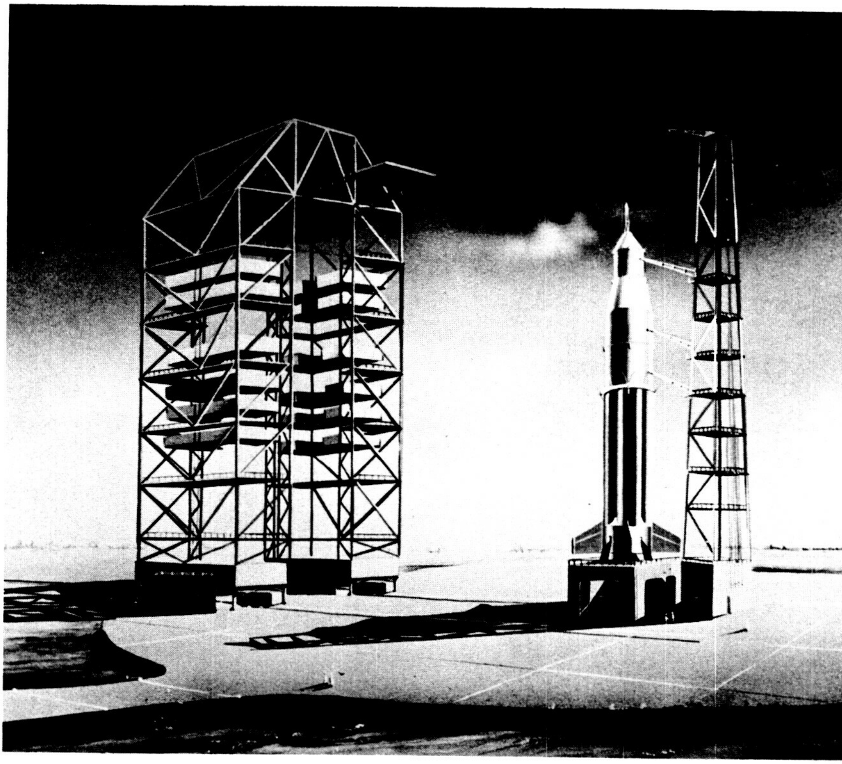

Figure 1–14. Apollo spacecraft atop Saturn C–1 launch vehicle.

Launch Vehicles Now in Use

NASA is continuing to improve and obtain reliable results from the launch vehicles that have played a major role in the Nation's space programs to date. These include the Scout, the Delta, the Thor-Agena B, and the Atlas-Agena B (fig. 2–1).

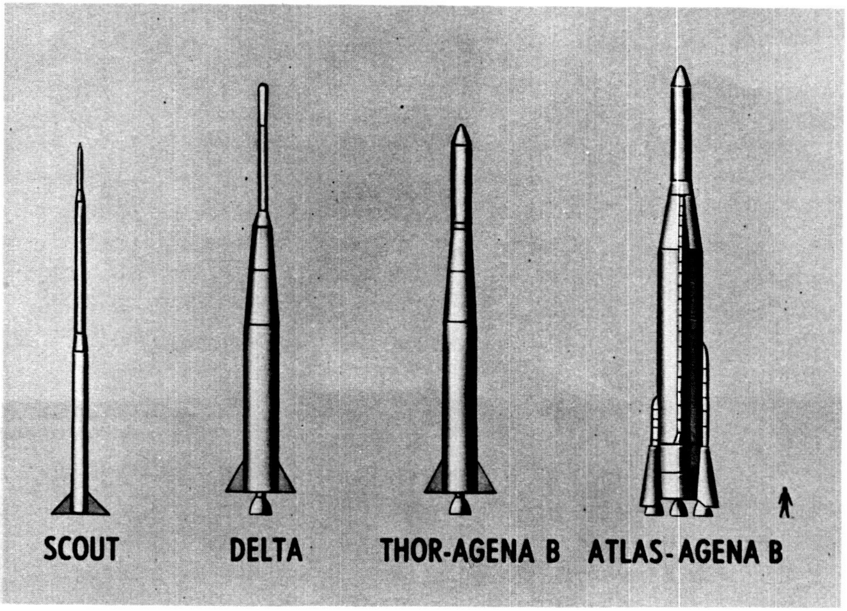

Figure 2–1. Launch vehicles now in use.

Scout

The Scout is a 4-stage solid propellant vehicle for launching small satellites, reentry experiments, and probes. It can put a 150- to 210-pound payload into a 300-mile orbit or lift small payloads as high as 4,000 miles in vertical probe experiments.

During this period, NASA conducted two development launches from Wallops Station, Va. In March, Scout No. 8 was launched as the first of a new series of re-entry experiments and Scout No. 9 carried an ionosphere probe to an altitude of approximately 4,000 miles.

On Scout No. 9, NASA used a new 23,000-pound-thrust third-stage motor (designated X–259) for the first time. Its satisfactory performance represents a significant step in the progressive effort to uprate the Scout.

Along with this advance, the other development programs to improve the performance of this launch vehicle proceeded on schedule. Both the higher thrust first stage (Algol IIa) and the new fourth stage (X–258) were successfully static fired. NASA will flight-test both stages during the next six months.

As part of the overall Scout program, NASA completed the new launch site for this vehicle at the Naval Missile Facility, Point Arguello, Calif. Less than 10 months elapsed between the initiation of this project and the first launch from it in April.

At Wallops Station, Va., NASA began to completely refurbish the Scout launch complex. The work included updating the launcher and the blockhouse consoles to match the present vehicle configuration and replacing the original cables. This effort, which began in April, was progressing on schedule at the end of the reporting period.

This launch vehicle is valuable to defense as well as space research. NASA and DOD have formally agreed that NASA will technically direct the Scout program and procure all Scout system hardware for both agencies. Thus, a single production line will deliver a standard vehicle that meets all mission requirements.

Production of Scout vehicles continued on schedule throughout the reporting period.

Delta

Delta, another of NASA's currently used launch vehicles, is considerably more powerful than the smaller Scout; it can place a 500-pound payload into 300-mile orbit. Delta, as shown in figure 2–2, consists of three stages—two liquid propellant and one solid.

During this period, Delta continued to be one of NASA's most reliable launch vehicles. It stretched its string of successes to nine with the following launches: On February 8, TIROS IV; on March 7, Orbiting Solar Observatory No. 1 (in the most nearly circular orbit yet achieved by the vehicle); on April 26, the first international satellite, Ariel or U.K. No. 1; and on June 19, TIROS V. (Delta No. 10 also launched the Telstar satellite in July, after the report period had ended.)

Because of Delta's proved effectiveness, NASA planned to order additional quantities from the manufacturer.

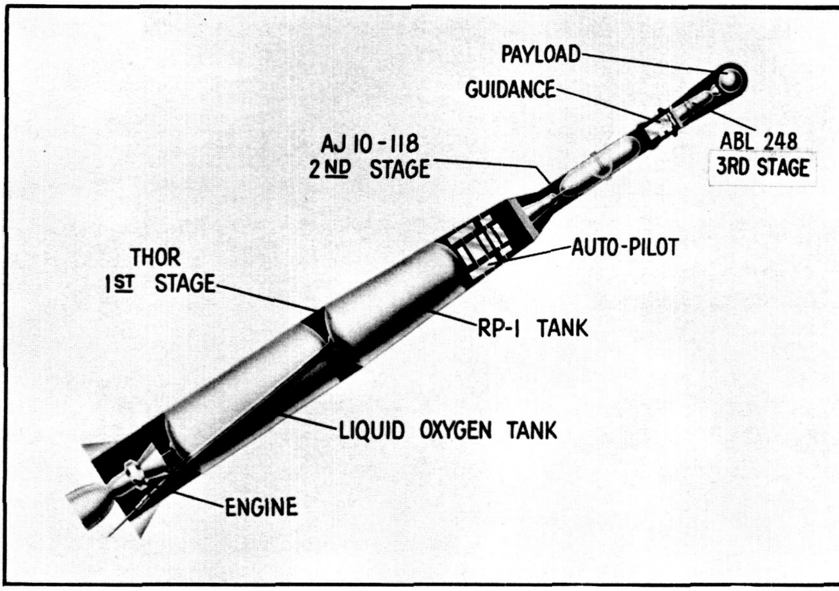

Figure 2–2. Cutaway of the Delta launch vehicle.

Thor-Agena B/Atlas-Agena B

NASA is continuing to make extensive use of the Air Force-developed Thor-Agena B and Atlas-Agena B launch vehicles. The Thor-Agenda B will launch scientific and other applications satellites requiring circular polar orbits. NASA is planning to use the Atlas-Agena B for certain meteorological, communications, and scientific satellite programs; for unmanned lunar and planetary programs (Ranger, Mariner); and for some phases of the manned flight programs (for example, placing an Agena B booster in orbit as part of Project Gemini's rendezvous and docking technique development).

In earlier launches, NASA used Atlas-Agena B vehicles with Rangers 1 and 2. Studies and analysis of data gathered from these launches resulted in vehicle changes to improve performance.

The first improved vehicle, launched January 26, carried an unmanned Ranger spacecraft (Ranger 3). However, the booster gave the vehicle a slightly greater velocity than planned; consequently, it did not achieve the planned moon-collision trajectory and is now in solar orbit.

On April 23, another Atlas-Agena B launched Ranger 4 (shown in fig. 2–3), with the same primary mission—lunar impact. This time the launch vehicle performed according to plan; the spacecraft (which failed to transmit data because of an electronic malfunction) landed on the moon 64 hours later.

During this period NASA was preparing two Atlas-Agena B vehicles for exploratory missions in the vicinity of Venus. The first vehicle was delivered to Cape Canaveral for extensive prelaunch checkout procedures. The second vehicle was in the final stages of preparation at the contractors' plants. (The first failed; the second succeeded. Both will be discussed in the next report.)

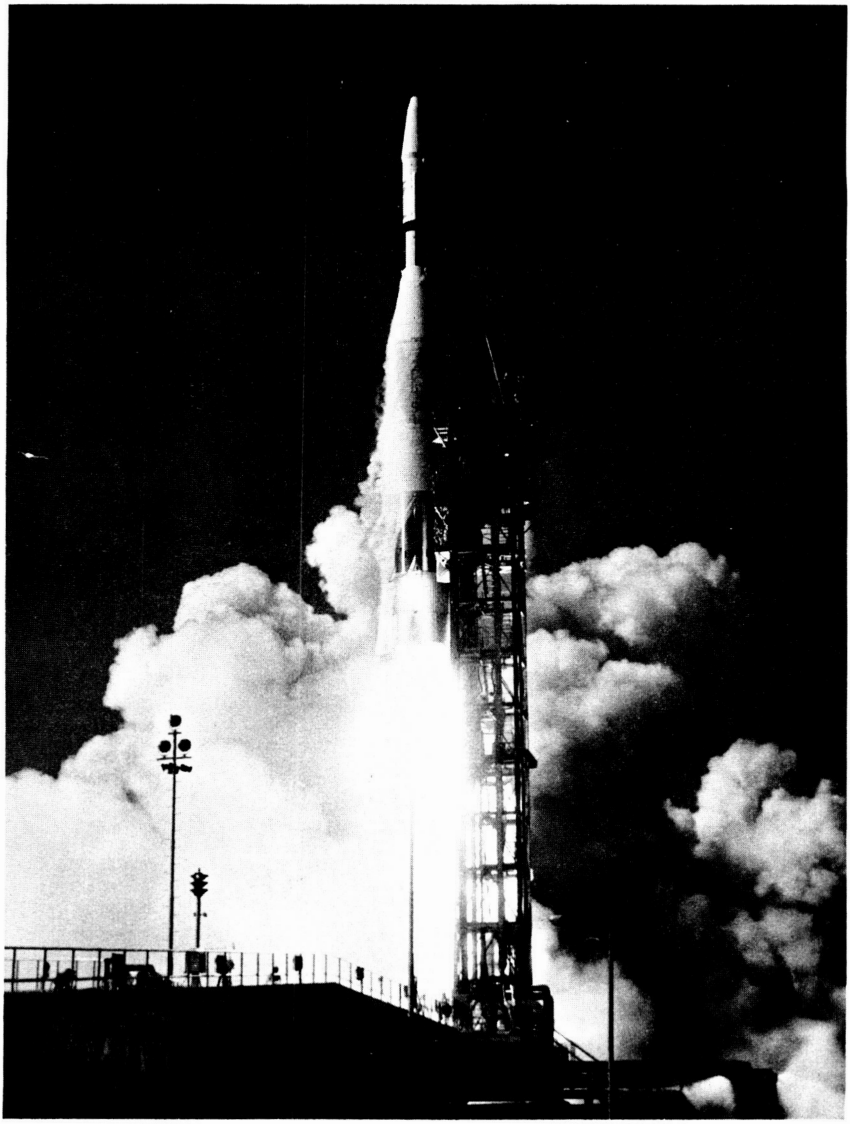

Figure 2–3. Atlas-Agena rocket launches Ranger 4.

The Agena B second stage of this launch vehicle has the significant advantage of being restartable. It can be cut off in orbit, coasted, then restarted by command from the ground. Because of this advantage, its ease of adaptability to mission requirements, and its increased reliability through a greater number of common launches, the U.S. Air Force and NASA agreed on the development of a completely standardized version, the Agena D. Accordingly, NASA has undertaken a study program to introduce this vehicle in the various NASA missions.

CHAPTER 3

Scientific Investigations in Space

NASA moved ahead in its scientific programs using unmanned vehicles to conduct (1) studies in geophysics and astronomy and (2) lunar and planetary investigations.

STUDIES IN GEOPHYSICS AND ASTRONOMY

NASA substantially advanced its studies in geophysics and astronomy. In this program, the Agency is using unmanned satellites, sounding rockets, and balloons to investigate the earth's atmosphere and ionosphere, its magnetic field, cosmic radiation, the Van Allen radiation region, and the sun. These phenomena must be better understood if man and his instruments are to journey safely into space.

OSO–1 (S–16) Orbiting Solar Observatory

OSO–1, one of the program's unmanned satellites, was the first orbiting solar observatory to be launched by NASA (see figs. 3–1 and 3–2). On March 7, a Delta launch vehicle boosted it from Cape Canaveral into a nearly circular orbit 350 miles above the earth.

OSO–1 pointed at the center of the sun with an accuracy roughly equivalent to aiming at a penny from a half mile away. It enabled the sun to be observed as it never had before—from a stabilized space platform whose view was not blocked by the curtain of air that makes up the earth's atmosphere.

Circling the globe every 97 minutes, OSO–1 transmitted about 1,000 hours of information on solar phenomena. The 440-pound spacecraft observed and measured over 75 solar flares and subflares, examined energetic particles in the lower Van Allen region, monitored the sun in a broad region of ultraviolet rays, measured X- and gamma radiation, and made surface erosion studies of materials.

OSO–1 operated almost perfectly for about 3 months; then a malfunction in the spin-control system limited its usefulness. Data were still being analyzed at the end of the reporting period.

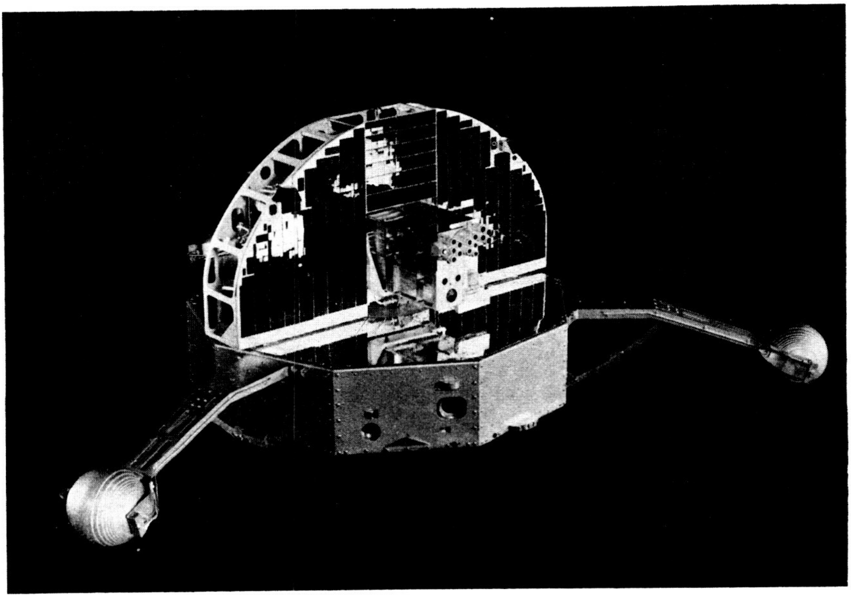

Figure 3–1. Model of orbiting solar observatory.

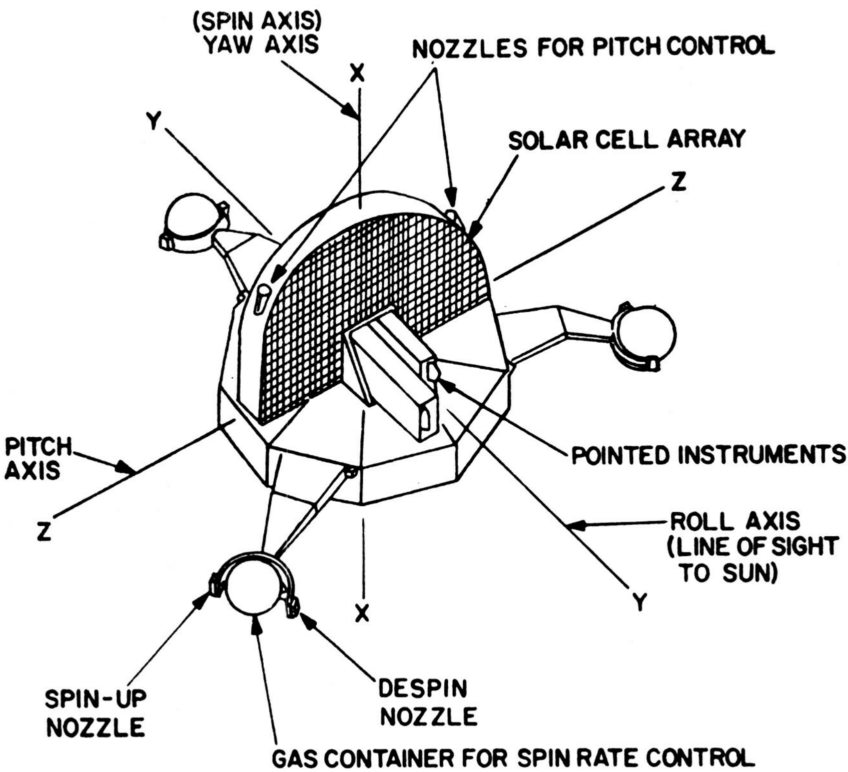

Figure 3–2. The orbiting solar observatory's configuration.

Ariel (S–51) Ionosphere Satellite

Ariel, illustrated in figure 3–3, was launched April 26 from Cape Canaveral by a Delta rocket. A joint effort of the United States and the United Kingdom, it is the first international satellite.

A short, fat cylinder about 11 inches long and 23 inches in diameter, the 132-pound Ariel is orbiting the earth every 100 minutes (apogee, 760 miles, perigee, 244 miles). Carrying experiments prepared by British scientists, it is collecting and transmitting data on cosmic rays, radiation intensities in the Van Allen belt, and solar phenomena.

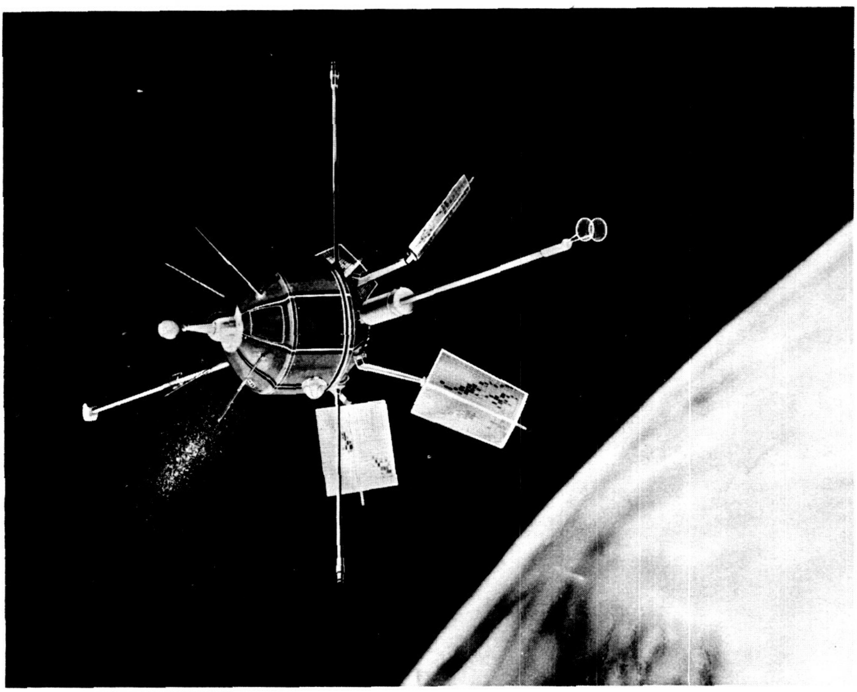

Figure 3–3. Ariel ionosphere satellite (sketch).

P–21a Electron Density Profile Geoprobe

The 147-pound P–21a geoprobe, illustrated in figure 3–4, was launched March 29 by a Scout rocket to an altitude of 3,900 miles. A nighttime probe, 30 inches long by 19 inches in diameter, it extended studies of the ionosphere above the altitude of 200 miles. These studies were begun October 19, 1961, by the P–21 daytime geoprobe (described in ch. 3 of NASA's sixth semiannual report to Congress).

The P–21a geoprobe investigated the nighttime ionization of the upper atmosphere because of its importance for radio communications and knowledge of sun-earth relationships. It transmitted excellent data on the density of ions and supplied the first description of the nighttime behavior of the helium layer in the upper atmosphere.

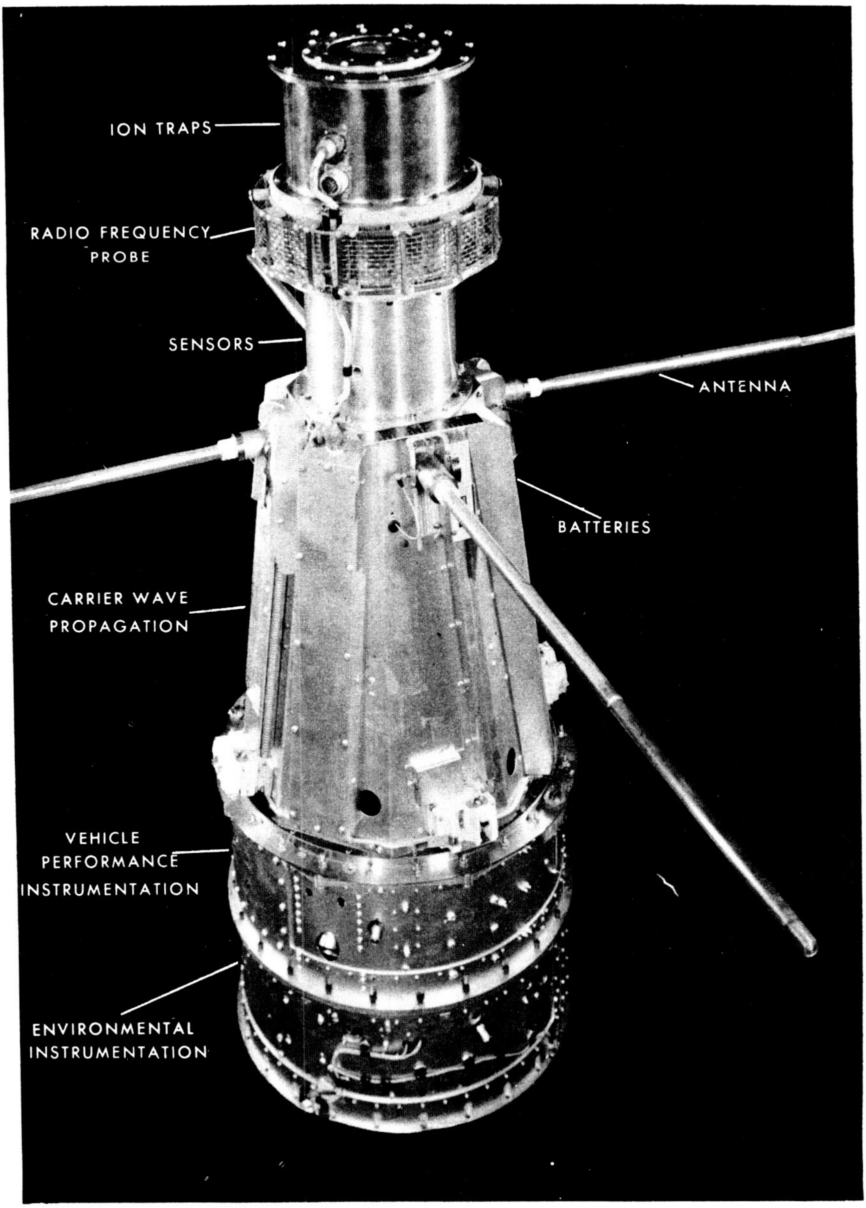

Figure 3–4. Payload of P–21a geoprobe.

Sounding Rockets

NASA launched a wide variety of instrumented sounding rockets during the report period. These are not as large as geoprobes and—rising from 50 to several hundred miles—do not reach the height of geoprobes. Like geoprobes, they are important space research tools for brief observations of the environment above the earth's atmosphere.

An Aerobee rocket was flown to test a method for stabilizing the attitude of rockets used for astronomical observations. It maneuvered its payload to point to three preprogramed targets. However, the test indicated a need for increased accuracy in the position-control system.

Four Nike-Cajun rockets and one Nike-Asp rocket were launched to altitudes of from 35 to 100 miles where they ejected trails of mixed sodium and lithium vapor that guided observers in making wind measurements.

Nike-Cajun rockets were used in the following investigations:

(1) Three measured electron temperatures in the nighttime ionosphere for comparison with daytime temperatures when the sun is actively imparting energy to the atmosphere.

(2) Three were launched at Wallops Island in a joint American and Japanese effort. The objective: To measure the electron temperature and the charge density in relation to altitude in the lower ionosphere. Data were being analyzed.

(3) A single rocket tested the behavior of a mass of water released at an altitude of 65 miles. This test was conducted in preparation for Project High Water.

Explorers VIII and IX Furnish New Data

Two Explorer satellites launched before this report period continued to furnish new data about the atmosphere:

(1) Explorer VIII, launched November 3, 1960, provided data on the composition of the upper atmosphere. These data revealed two transition regions in the upper atmosphere—one from the oxygen to the helium ion; another from the helium to the hydrogen ion. This information agrees with other indications that a helium layer of variable thickness and altitude lies between the oxygen and hydrogen ions at heights varying from 600 to 1,500 miles above the earth's surface.

(2) Explorer IX, launched February 16, 1961, showed that the density of the atmosphere at an altitude of about 500 miles varies with the sun's activity. Atmospheric density of the upper atmosphere should therefore vary with changes in solar activity during the sun's 11-year cycle.

Project High Water

Project High Water was conducted as a secondary mission to the Saturn SA–2 launching of April 25. Ninety-five tons of ballast water released at an altitude of 65 miles produced a white cloud about 6 miles wide and radio noise that most likely had its origin in electric discharges arising from charge separation in the cloud.

The experiment demonstrated that a large quantity of volatile matter, such as water, released into the upper atmosphere produces no major effects in the atmosphere and no catastrophic aftereffects in the earth's environment.

LUNAR AND PLANETARY INVESTIGATIONS

NASA extended its efforts to meet the objectives of its unmanned lunar and planetary programs: Ranger and Surveyor, for investigations of the moon; and Mariner and Voyager, for studies of Venus, Mars, and interplanetary space.

By these programs NASA is seeking (1) scientific data on the characteristics of the moon, the planets, the sun, and the environment of space, and (2) engineering data that will advance spacecraft technology. These programs will supply information vital to the success of manned flights to the moon (Project Apollo). They may also provide answers to fundamental questions about the origin of the moon and the early history of the solar system.

Ranger

During the period, NASA launched Ranger 3 and Ranger 4, the first of a series of spacecraft designed to make hard landings on the moon and to transmit data on its composition, structure, and history. (In the previous period, Rangers 1 and 2 made preliminary test flights on trajectories not intended to hit the moon.)

To gather lunar data, the Ranger spacecraft carries a vidicon television system, a gamma ray spectrometer, a radar reflectivity experiment, and a seismometer (to measure moonquake and meteor activity) in the capsule to be hard landed on the lunar surface. (See fig. 3–5.)

Ranger 3 and Ranger 4 failed to complete their missions. However, Ranger 3 provided scientific and engineering information that will be utilized in other Ranger flights. And Ranger 4 demonstrated that future spacecraft in this program can be shot moonward with accuracy.

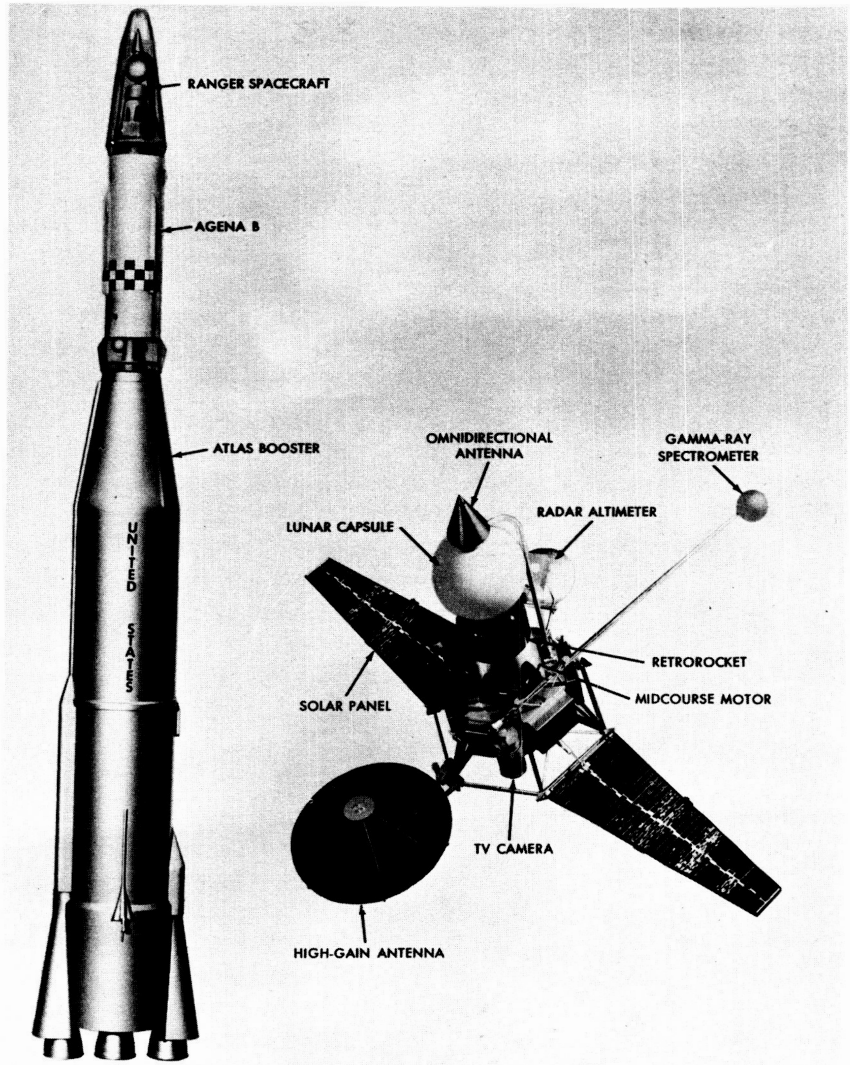

Figure 3–5. Ranger spacecraft and launch vehicle system.

Work progressed on Rangers 5 and 6, and Rangers 7, 8, and 9 entered the early developmental stage.

Ranger 3.—Ranger 3 was launched from Cape Canaveral January 26, by an Atlas-Agena B vehicle. It missed the moon by about 23,000 miles because it received too strong a boost from the Atlas rocket. It then went into solar orbit.

Although Ranger 3 did not complete its lunar exploration mission, it successfully carried out other complex activities. Its attitude-control system functioned perfectly and "acquired" the sun and earth: It alined its flight axis so that its solar panels were in a "sun-lock" or alined to face the sun. In this attitude, the panels were able to produce electrical power for the spacecraft's operation. Then while maintaining its lock on the sun, Ranger extended its high-gain antenna (for telemetry and television transmissions to earth) and used its nitrogen jets to aline itself and the antenna into an "earth-lock." The high-gain antenna transmitted properly.

Ranger 3 demonstrated that these complex operations can be performed while the spacecraft is in a trajectory to the moon. (Such operations in the previous Ranger 1 and 2 flights were performed in low earth orbits.)

Ranger 3 responded to orders transmitted by NASA's Goldstone (Calif.) Tracking Station directing it to perform a midcourse corrective maneuver. It then reoriented itself and again acquired the sun and earth. (See fig. 3–6.)

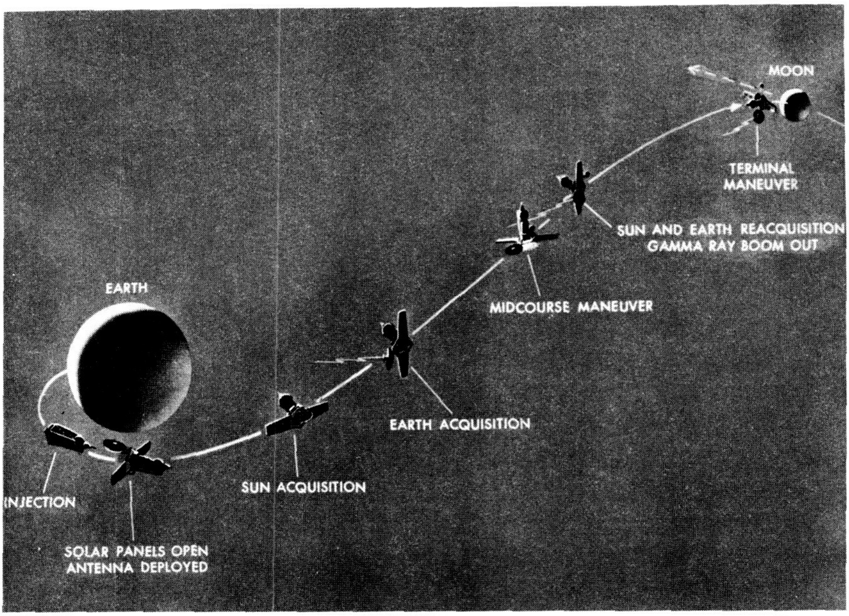

Figure 3–6. Flight plan of Ranger 3 spacecraft.

The gamma-ray spectometer, operating for 50 hours, provided information on the environment Ranger passed through on its way toward the moon. This data will be valuable for interpreting future gamma-ray experiments and designing more advanced instrumentation.

Ranger 4.—Ranger 4 was launched April 23. Sixty-four hours later it became the first U.S. spacecraft to land on the moon.

Ranger 4 was unable to transmit scientific or technological information because an electronic malfunction prevented its telemetry system from operating. However, the seismometer transmitter signal functioned and enabled the NASA Deep Space Network to track the spacecraft to the end of its flight.

Ranger 5.—In preparation for its launching late in 1962, Ranger 5 underwent systems tests and checkout. The scientific payload on Ranger 5 will be the same as that flown on Rangers 3 and 4. (For details, see ch. 5, NASA's sixth semiannual report to Congress.)

Rangers 6, 7, 8, and 9.—The Ranger project provides for four additional lunar flights to be carried out during 1963. The primary mission of these flights will be to obtain highly detailed television pictures of the lunar surface.

The spacecraft will be similar to that used for the previous three flights, except that the retrocapsule on Rangers 3, 4, and 5 will be replaced by a cluster of six television cameras fixed to the hexagonal "bus," or standardized frame that can carry a variety of equipment.

Rangers 6, 7, 8, and 9 will also contain several nonvisual experiments for studying radiation and cosmic dust between the earth and the moon. An acoustic detector will measure interplanetary dust particles, and a magnetometer will provide information on magnetic field fluctuations between the earth and the moon and in the lunar environment.

Mechanical assembly of the Ranger 6 spacecraft was completed in June, and assembly of the television subsystem test model progressed. Work began on nonvisual experimental prototypes for Rangers 7, 8, and 9.

Surveyor

NASA continued preparatory work on the second major unmanned lunar program—Surveyor. The program's objective: To develop the technology required for operations near the moon and on its surface and for collecting and transmitting to earth data that will greatly increase knowledge of the moon and its environment.

NASA is working on two Surveyor spacecraft: one, to make soft landings on the moon; the other, to orbit the moon. To achieve maximum reliability and to minimize costs, NASA plans to make the greatest possible use of the same basic structure, telecommunications and attitude control systems, components, and launch vehicle (the Atlas-Centaur) for these two spacecraft—the Lander and the Orbiter.

NASA progressed in developing and testing components and systems of the Surveyor Lander. (See fig. 3–7.) Important structural and drop tests were performed on the spacecraft, and an engineering mockup was constructed.

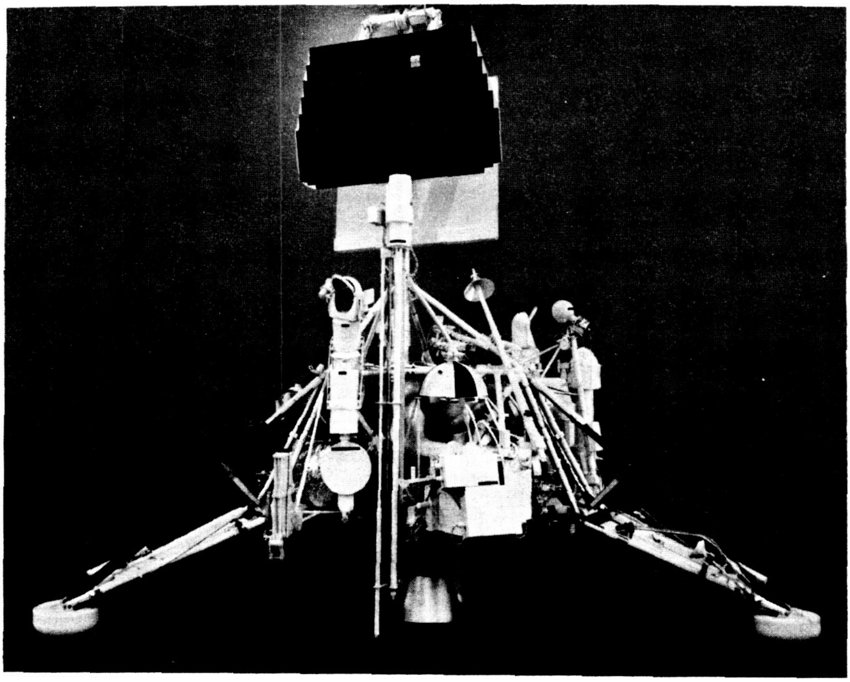

Figure 3–7. Surveyor Lander spacecraft.

Design studies of the Orbiter were undertaken. NASA's Jet Propulsion Laboratory developed performance requirements for the Orbiter's optical-camera subsystem, called Visual Instrumentation Subsystem (VISS), and NASA submitted these to industry for proposals. The Agency also invited the national scientific community to participate in the Orbiter project and to propose correlated scientific experiments to accompany VISS.

Mariner

In the Mariner program, NASA plans to extend its unmanned exploration of space by spacecraft to "fly by" Venus and Mars and make observations and measurements of these planets and of interplanetary space. The spacecraft for this program are Mariner 1 and 2, for fly-by flights to Venus, and Mariner 64 for Mars and Venus missions.

The Mariner 1 and 2 spacecraft and the mission to Venus are described in NASA's sixth semiannual report to Congress, chapter 5, under Mariner R, the previous name. During the period, the Jet Propulsion Laboratory assembled and tested the Mariner 1 and 2 spacecraft in preparation for launching. The scientific instruments were calibrated. Late in May, the completed spacecraft were shipped to Cape Canaveral.

In this period, Jet Propulsion Laboratory completed the preliminary design of the Mariner 64 spacecraft, and NASA tentatively selected the following experiments to be carried on the flight.

1. A TV system, infrared spectrometer, and ultraviolet spectrometer to scan the planet's surface and to gather electromagnetic data on the planet's temperature and atmosphere.
2. A set of magnetometers to determine the strength and direction of the magnetic fields in interplanetary space and those produced by the planet.
3. Two types of plasma probes to determine the properties of lower energy charged particles in space and in the vicinity of the planet.
4. Various detectors sensitive to energetic particles (for example, solar and galactic cosmic rays as well as particles trapped near the planet) to measure the energies, directions, and other characteristics of these particles.
5. Cosmic dust detectors, to determine the size, speed, direction, and distribution of particulate matter in space.

NASA also considered having Mariner 64 eject a capsule to the surface of Venus and Mars. It completed studies on the conditions which might be encountered as the planned capsule enters the atmospheres of these planets. Instrumentation considered for the capsule included devices to measure trapped magnetic fields, dynamic properties (for example, pressure, temperature, and density) of the atmosphere, the types and quantities of the gases making up the atmosphere, and forms of life or organic constituents in the atmosphere.

Voyager

NASA also continued studies on the various subsystems required for Voyager, an advanced unmanned spacecraft to be launched about 1966 by a Saturn-class vehicle. Voyager will be capable of landing a heavier capsule than that carrier by Mariner 64. It will also be able to orbit Mars.

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Satellite Applications

During the first half of 1962, the United States employed its meteorological satellites in analyzing and forecasting the weather and tested its communications satellites in experimental coast-to-coast television transmission.

In February and May meteorological satellites played a vital role in the Nation's expanding space program when they provided supporting data for the first two manned orbital flights of Project Mercury.

Telstar—a cooperative NASA-American Telephone & Telegraph Co. active communications satellite now under construction—was being designed to receive and retransmit telephone calls, messages, and photographs from station to station on earth, and experiment with transatlantic television.

Research and development continued on NASA's Project Relay—marking the Agency's entry into the active communications satellite field—as well as on the Telstar, Echo, Multilaunch, and Syncom communications projects.

METEOROLOGICAL SATELLITES

Meteorological satellites are rapidly attaining status as a key tool of weather forecasting. Weathermen are finding the TIROS satellites an invaluable aid in preparing weather analyses and forecasts, particularly in detecting and keeping track of hurricanes and tropical storms.

The increasingly accurate long-range weather predictions resulting from information transmitted by these spacecraft should benefit, among others, farmers, builders, vacationists, resort owners, promoters of sports events, and sponsors of fairs and similar gatherings.

TIROS

TIROS satellites launched during this period added further to the utility of the series.

TIROS IV, orbited on February 8 at an inclination of 48.3°, and similar in configuration and instrumentation to TIROS III (see chap. 2, NASA's sixth semiannual report) had transmitted 23,370 pictures as of June 30. The satellite was placed into an orbit having an apogee of 525 miles, a perigee of 441 miles, and a period of 100.4 minutes.

From the picture transmissions, meteorologists have been able to prepare 795 cloud analyses. TIROS IV provided supporting data for the first two manned orbital flights of Project Mercury. It transmitted excellent pictures of the sea ice in the Gulf of St. Lawrence and surrounding areas. It also supplied extensive operational and basic research data on cloud formations and heat radiation from the earth and its atmosphere. In addition, this weather satellite served as a source of data for special storm advisories to Australia, Japan, the Malagasy Republic, Mauritania, and the Republic of South Africa. It continues, through NASA, to serve U.S. Weather Bureau stations and military detachments.

TIROS V was launched from Cape Canaveral on June 19, timed to provide maximum weather information during the peak of the 1962 hurricane season in late August and September.

This weather satellite, placed in orbit by NASA's reliable 3-stage Delta rocket, circles the earth every 100.5 minutes at an altitude of approximately 367 to 604 miles. It is the first TIROS launched into an orbit that is inclined 58° to the Equator; others were inclined at approximately 48°. Its TV cameras were thus able to view the Northern Hemisphere for the first 10 days after launch, spend the next 38 days over the Southern Hemisphere, and then return to the north. This scheduling places the satellite over the Northern Hemisphere's hurricane and typhoon belts during the season for these tropical storms. (In order to meet this schedule it was launched with its radiation sensors inactive.)

Late in April an unknown spurious signal turned on the TIROS II beacon. (TIROS II, the second in the TIROS series, was launched November 23, 1960.) Electronic components of the satellite and its radiation tape recorder were found to have been operating for 1½ years and were still able to supply limited usable data—in spite of a planned meteorologically useful life of only a few months.

After an engineering investigation, TIROS II was turned off again early in May. Continued operation was considered undesirable because its power would be reduced so much that the spacecraft could not be silenced. It would thus be limited to transmitting a weak beacon signal which would tie up radio frequencies required for other purposes.

NASA continued planning to launch three or four more TIROS satellites at about 4- to 5-month intervals. These satellites will be phased out after their more sophisticated successor, Nimbus, becomes operational. A TIROS and at least the first Nimbus satellite will be in orbit simultaneously to insure coverage at all times until Nimbus is proved out.

Nimbus

The Nimbus meteorological satellite is designed to point toward earth at all times when in orbit. Furthermore, its instruments will be able to receive data from the entire earth at least twice a day (TV cameras in daylight; infrared sensors day and night), since it will be launched in a near polar orbit.

The satellite will repeat coverage of about the same geographic area at the Equator about every seventh orbit (i.e., every 12 hours) and somewhat more frequently near the poles. However, since every other pass is at night, 14 orbits or about 24 hours will elapse before Nimbus passes the same area again in daylight.

Complete global coverage for Nimbus is planned through two data-acquisition stations. (See fig. 4–1.) One of these is to be in Fairbanks, Alaska; negotiations for the other, at an east-coast site, continued.

The basic Nimbus spacecraft will include a control and stabilization system, a sensor and electronic ring compartment, infrared scanners, and initially three TV cameras. (See also ch. 9, NASA's fifth semiannual report.) A mockup of the spacecraft was being assembled and components were being tested. (See fig. 4–2.)

NASA is cooperating with the Weather Bureau toward setting up a National Operational Meteorological Satellite System. As an interim measure operational Nimbus-type spacecraft will be interspersed with Nimbus research and development satellites—each type providing data for weather analysis and forecasting.

Aeros

Proposals for a study contract to determine feasibility and problem areas of the Aeros meteorological satellites were under consideration during this period. (See ch. 9, NASA's fifth semiannual report.)

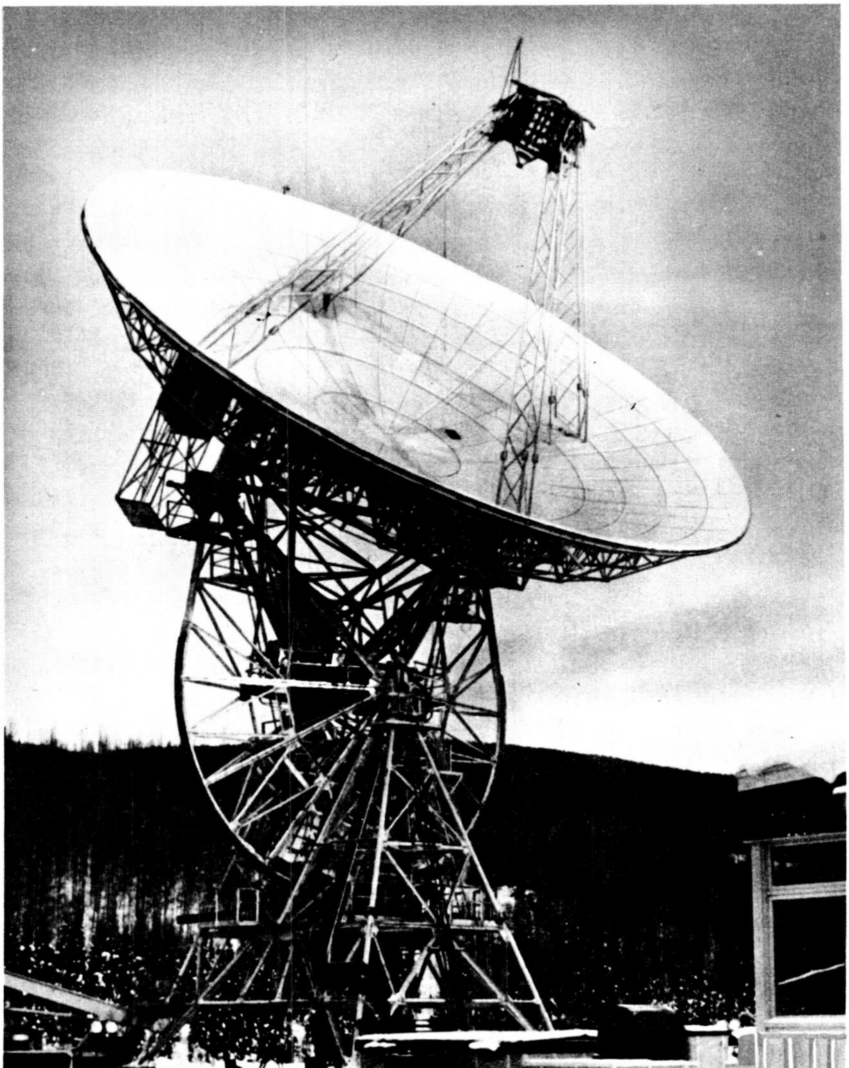

Figure 4–1. Nimbus data acquisition station.

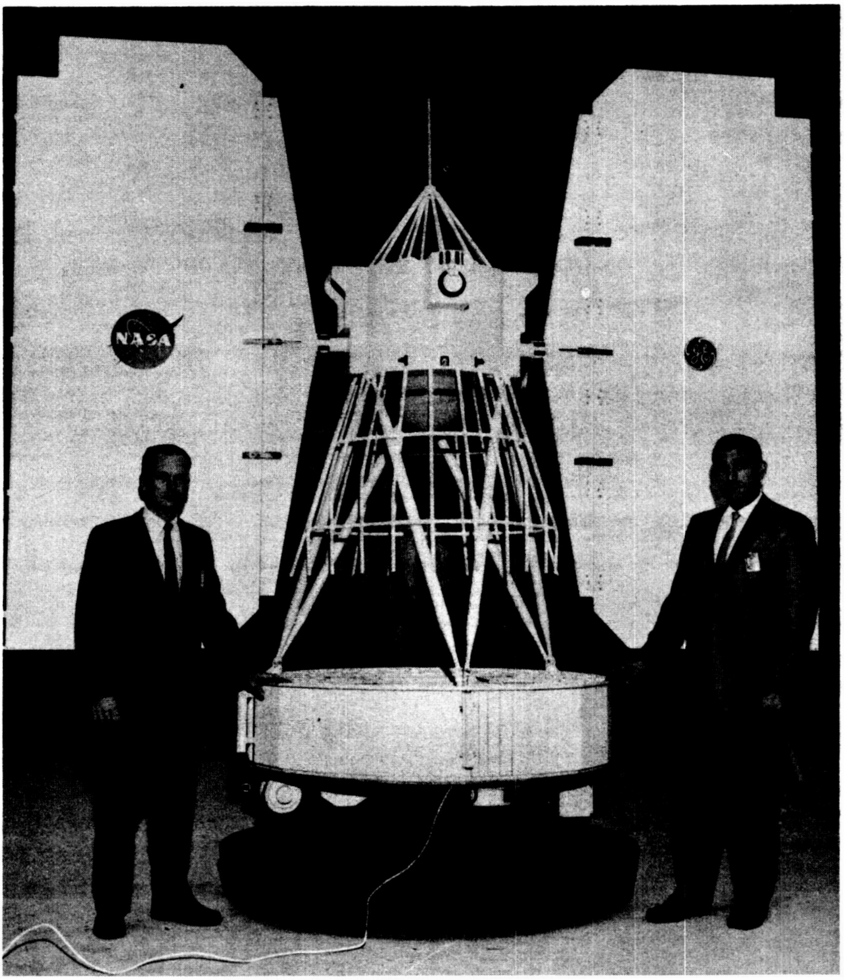

Figure 4–2. Mock-up of Nimbus spacecraft.

METEOROLOGICAL SOUNDING ROCKETS

Meteorological sounding rockets are used in studies of the atmosphere above the operating range of balloons (100,000 feet) and below the effective observational altitude of satellites (100 miles). Two meteorological rocket sounding systems are employed to determine the structure of the atmosphere. One, the large meteorological rocket sounding system, measures the atmosphere generally between altitudes of 40 to 70 miles. The other, the small meteorological rocket sounding system, measures the atmosphere between 20 to 40 miles.

Large meteorological rocket soundings use solid propellant rockets of the Nike-Cajun type with several different payloads. These payloads consist of grenades, sodium vapor, and pitot-static tubes (to measure impact and static pressures). (See fig. 4–3.)

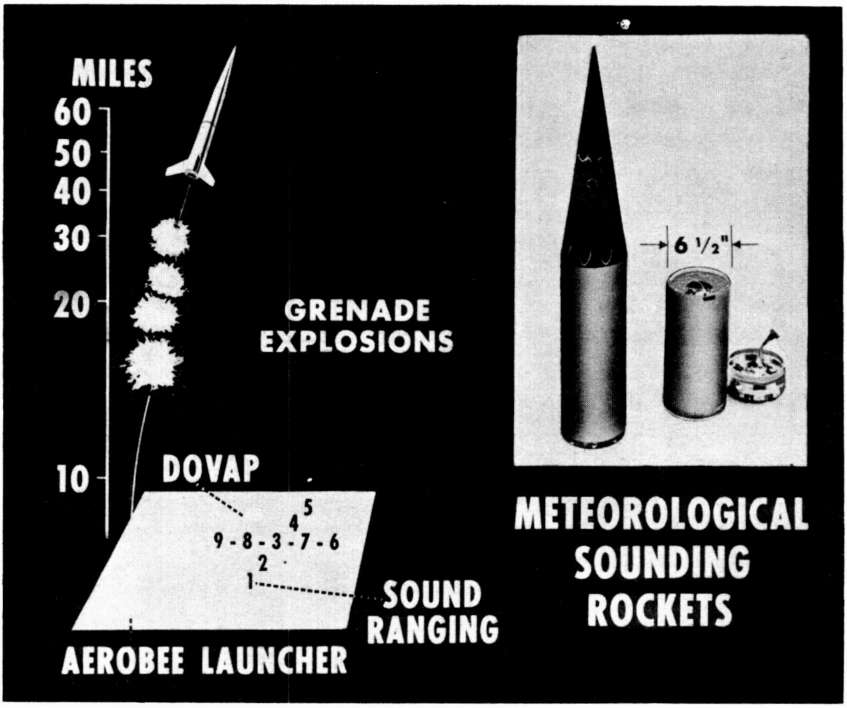

Figure 4–3. Meteorological sounding rockets.

Seven rocket grenades launched from Wallops Island during this period provided measurements between altitudes of 30 and 50 miles. Five of the launches were closely coordinated with the sodium vapor experiments (see ch. 3, p. 49) and provided information between 30 and 120 miles, with comparative data for the two types of experiments between 40 and 55 miles.

The small rocket soundings use rockets of the Arcas and Loki type with a number of different sensors which are ejected at apogee and descend to the surface. These sensors are chaff, parachute, inflated sphere, and bead thermistor.

The various small meteorological sounding techniques used at nine meteorological stations, comprising the cooperative NASA-Army-Navy-Air Force network in the United States and Canada, are supplying range support and research data pertaining to the upper atmosphere. (See fig. 4–4.)

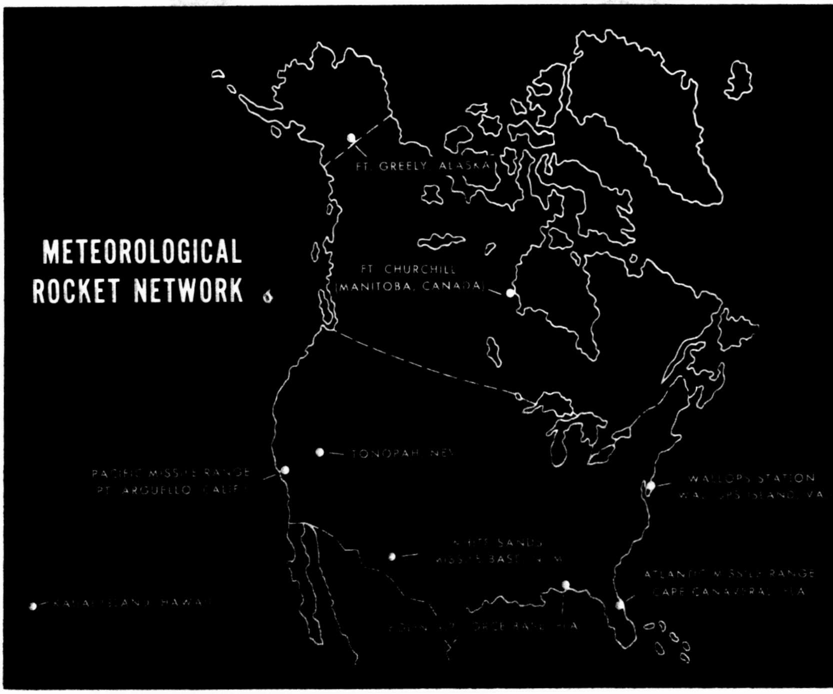

Figure 4–4. Meteorological sounding rocket stations.

During this 6-month period 40 small Arcas and Loki type rockets were launched from Wallops Island—some of these for the Navy and Air Force. The rockets furnished wind and temperature data for the region 20 to 45 miles above the earth.

Information from the nine stations revealed that cyclonic systems form and propagate in the upper stratosphere and mesosphere (19 to 50 miles above the earth), and that reversals occur in the hemisphere circulation from season to season. During the winter, remarkable rapid changes in hemispheric flow patterns and indications of the propagation of high-level disturbances downward were also found.

It is planned that the U.S. Weather Bureau will assume management of the operation of the fully developed meteorological rocket network. Until this is accomplished the NASA-Army-Navy-Air Force cooperative arrangement will remain in force. During this transitional period about 100 Arcas and Loki rockets per year will be launched from Wallops Island.

COMMUNICATIONS SATELLITES

During this report period research and development continued on Project Relay—NASA's first active communications satellite—as well as on the Syncom, Telstar, Multilaunch, and Echo projects.

(*Active* communications satellites receive, amplify, and retransmit using internal power supply; *passive* communications satellites, such as Echo, simply reflect signals from one terminal of the system to another.)

Relay

Relay will be tested to determine whether it can transmit wideband television and telephone signals, perform reliably in the Van Allen radiation belt, measure radiation damage to electronic equipment, and provide experience for an eventual operational system.

The 170-pound Relay I is scheduled to be launched into an elliptical orbit (apogee, about 4,500 miles; perigee, about 700 miles) by a Thor-Delta vehicle during the fourth quarter of 1962. Work continued on a prototype of the satellite, and its subsystems were tested. Modifications and changes will be incorporated into flight models.

Supporting ground stations will be located at Mojave, Calif., Andover, Maine, and Nutley, N.J. Joining them will be the British Post Office station in Goonhilly, England, the French Pleumeur-Bodou station, and a transportable station in Rio de Janeiro, Brazil. Additional stations are being built in Italy and West Germany. Other nations are planning to participate in this network.

Syncom

Syncom—NASA's first attempt to launch a satellite into a synchronous, 24-hour orbit—will circle 22,300 miles above the earth. The spacecraft's orbital period will be the same as that of the rotating earth below. In this initial experiment the orbit will not be equatorial but somewhat inclined. As a result, the satellite, instead of appearing to be stationary over a point on the earth below, will appear to move to the north and south of the Equator, ascribing a figure-8 type path. (See fig. 4–5.)

Syncom is scheduled to be launched by a Thor-Delta vehicle during the early part of 1963; a prototype model of the satellite was completed during this reporting period.

Syncom is a joint NASA-Department of Defense project. NASA will provide the launch vehicle, spacecraft, tracking and orbital control. DOD will provide the ground communications equipment and support. The spacecraft is drum shaped, 28 inches in diameter and

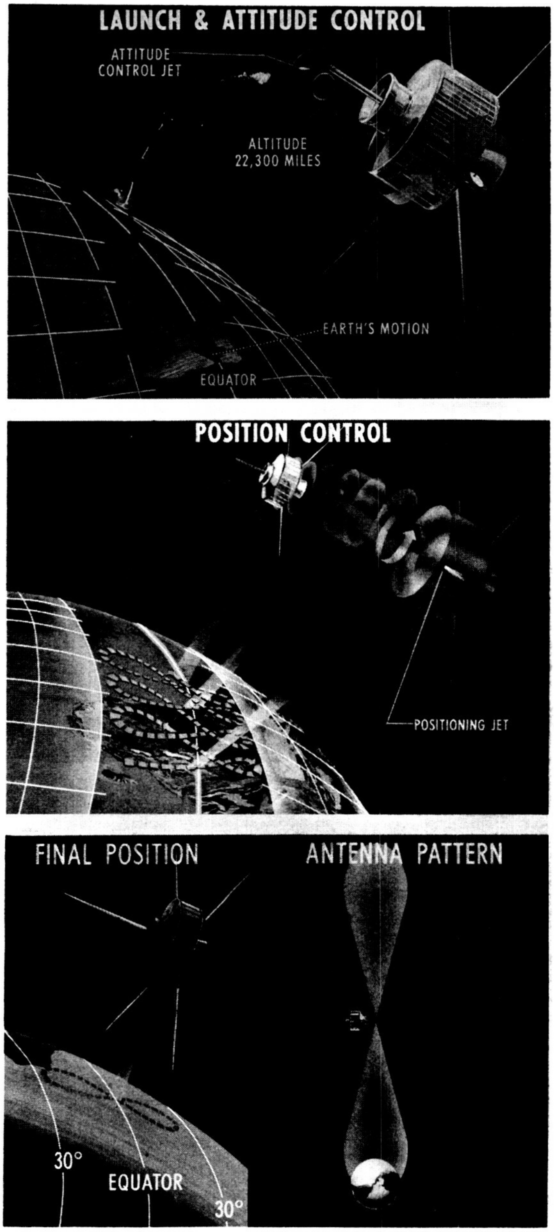

Figure 4–5. Syncom sequences.

25 inches high, and weighs about 145 pounds, including the "apogee kick" motor that gives the added thrust required to put the spacecraft into a circular nearly synchronous orbit.

Telstar

Telstar, the Nation's first active communications satellite, was being built by the American Telephone & Telegraph Co. in cooperation with NASA. Its objectives are to test wideband communications, effects of radiation on critical components, satellite life, and spacecraft performance in low orbit.

The spacecraft—scheduled to be launched by a Delta vehicle from Cape Canaveral in July—is 34½ inches high and weighs about 170 pounds.

Telstar is unique in several respects. The experiment represents the first time that a private company has designed and built a satellite (cost—an estimated $50 million) and paid NASA for its launching and related services (about $3 million per launch). In addition, A.T. & T. is building the spacecraft and ground terminal at Andover, Maine. The station's 60-foot horn-type antenna will be used in NASA's Project Relay.

Results of the experiment will be applied to the overall NASA communications satellite research and development program designed to provide the technology necessary to establish an operational system of communications satellites at the earliest possible date.

NASA's eighth semiannual report—July 1 through December 31, 1962—will evaluate Telstar's performance and describe future plans for satellites of this and related types.

Echo

Echo I (launched August 12, 1960) remained in orbit, although later becoming wrinkled and probably no longer in spherical shape. However, this passive satellite continued to be used in communications experiments—as late as April 24, 1962, televising a picture from California to Massachusetts for the Air Force.

Echo II, a 135-foot-diameter rigidized sphere, is scheduled for launching during the early part of 1963. (See fig. 4–6.) It will be placed in orbit 700 milles above the earth, be inclined 80° to the Equator, and will have an estimated lifetime of 680 days.

As a first step in the flight program leading to the orbiting of this sphere, a vertical test was carried out from Cape Canaveral on January 15, using a Thor vehicle. The rocket carried a TV camera for remote monitoring and a recoverable capsule containing a movie camera.

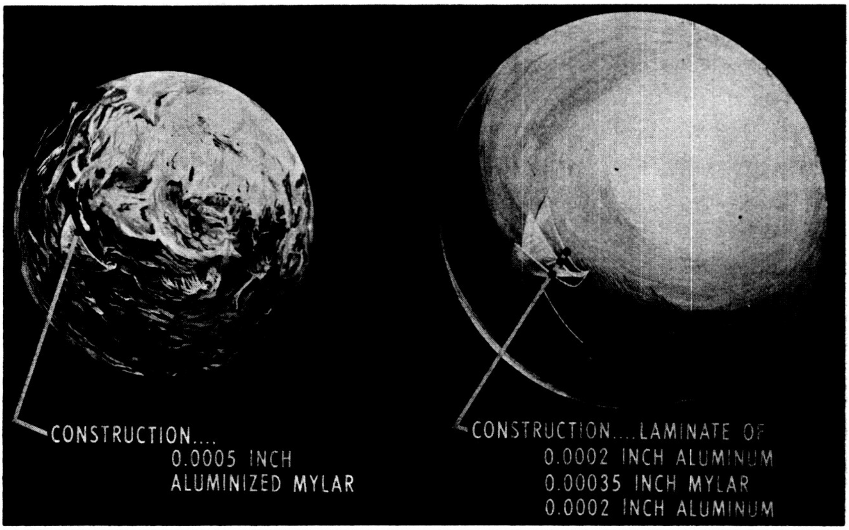

Figure 4–6. Left, Echo I (100 ft in diameter, wt 135 pounds); Right, Echo II (135 ft in diameter, wt 500 pounds).

The balloon was ejected and inflation started at an altitude of about 200 miles. However, it ruptured, probably as a result of too rapid inflation. A second vertical test of Echo II will be conducted during the third quarter of 1962.

Multilaunch Concept

Study continued on the multilaunch concept under investigation by NASA. This project envisions placing three to five passive satellites into orbit with one launch vehicle. Such a multiple launch will produce substantial savings in launching costs. A study to determine design considerations and problem areas was continued.

CHAPTER 5

Propulsion and Power Generation Research and Development

Propulsion and power generation represent two research and development areas of vital concern to NASA. Progress in both areas is a prerequisite to improving the performance and effectiveness of all spacecraft, satellites, probes, and onboard operating systems. To achieve the desired progress, NASA continued to conduct experiments and studies on a broad front.

PROPULSION RESEARCH MAKING HEADWAY

During the period, NASA pressed to expand its propulsion technology, not only as it applies to boosters and launch vehicles but also as it applies to spacecraft attitude, guidance, and control. Besides seeking to develop boosters and stages in the multimillion-pound-thrust classes, NASA projects must also develop the very-low-thrust engines and motors that permit precise control of both orbital and exploratory vehicles. Additionally, these projects are concerned with thrust control and variation, stop-start capability, extended inoperative periods, performance in different environments, and duration of operating time. NASA activities in these projects encompass liquid, solid, nuclear, and electric propulsion.

Liquid Propulsion

NASA's current programs in liquid propulsion are helping to solve problems concerning engines being developed today and to provide the information needed for future propulsion systems. These studies are specifically directed toward spacecraft and launch vehicle engines; in addition, they will broaden the overall supporting technology.

Spacecraft Engines.—NASA completed investigations to determine basic propulsion requirements on board spacecraft for a variety of missions, including rendezvous and lunar flight. These apply to such projects as Gemini, Apollo, and various other space flight missions.

Also, in a series of related studies, NASA was seeking solutions to problems of thrust control, propellant flow, and engine feeding. A survey of controllable thrust concepts disclosed two promising possibilities; these were being pursued further by designing and fabricating experimental models and by conducting hot firing tests. Under another program, NASA conceived methods for expelling propellants from tanks into rocket systems: bladders of various types of materials, geometric techniques, and methods that employ new physical concepts.

A third study continued investigating the use of pressurized gasses to feed propellants to the engines. Still another study compared pressure-fed and pump-fed systems; this one also assessed tankage problems that involve such things as zero gravity effects, meteoroid protection, and materials.

Of particular concern is the matter of longtime storability and restart capability of midcourse propulsion systems. One such system developed for the Mariner program was successfully demonstrated. It was fired for 60 seconds, stored for more than 8 months, and then successfully refired in two more tests. This system provides a thrust of 50 pounds and uses hydrogen fuel.

Launch Vehicle Engines.—At the other end of the thrust scale, NASA continued development of large liquid rocket engines to be used in launch vehicles. Significant progress was made, highlighted by the first full-thrust, full-duration firings of the F–1 engine and the successful completion of test milestones for the RL–10 engine, clearing it for flight use. In the area of large-engine research, two concepts for 24-million-pound-thrust engines were evolved: the staged-combustion cycle (combustion in two steps), and the toroidal (doughnut-shaped) chamber. In addition, NASA studied preliminary designs for liquid rocket engines of 6 million or more pounds of thrust.

In another research effort, NASA studied combustion oscillation and acoustic behavior of jets in liquid rocket engines. As part of this effort, the researchers used unconventional nozzles that yielded high off-design thrust performance. Results of this endeavor will help solve attitude control problems of launch vehicles.

General Liquid Rocket Engines Supporting Technology.—In support of both spacecraft engines and launch-vehicle engines, NASA continued research to solve two problems: the measurement of propellant flow and the measurement of combustion chamber pressure.

After completing concept and design work, NASA arrived at a sound, practical flowmeter. Called the induction flowmeter, this device can measure the flow rate of both petroleum-base fluids and other dielectrics such as cryogenics (extremely cold). The device has no moving parts and can become part of the flight instrumentation for measuring propellant flows and controlling propellant mixture ratios.

For combustion chamber pressure measurement, it is necessary to have small, reliable, high-frequency response devices that can withstand high heat fluxes. NASA obtained design data and specifications for such a device—a small, high-performance transducer. Work on this device is continuing so that it will be available soon for research and development, for engine checkout instrumentation, and for onboard flight instrumentation.

Solid Propulsion Programs

NASA made progress in solid propulsion programs investigating current applications and technology required to accomplish future missions.

Multilayer Solid Propellant Motor.—NASA demonstrated a high-performance solid rocket motor that used multiple layers of propellants with different burning rates. The motor weighed about 600 pounds; the propellant comprised more than 95 percent of this weight, making the motor one of the most efficient designs ever tested.

Steering and Attitude Control Concepts.—The agency virtually completed a steering package system for controlling the flight of solid vehicles. This system contains a central solid motor that supplies hot gas to eight nozzles through a series of continuously variable valves. The agency also obtained a satisfactory solid propellant fuel for this system.

Acoustical Problems Associated With Large Solid Propellant Boosters.—Through a contract, NASA completed a study of the acoustical problems associated with large solid boosters. Tentative conclusions of the study are as follows: (1) The noise level of the extremely large boosters is predictable and will not be much higher than that of the Saturn C–1 first stage; (2) sonic fatigue failure of solid boosters will probably not occur because of the noise level, the short exposure time, and the structure of the booster; (3) the problem of equipment malfunction should be no greater on a 20-million-pound-thrust booster than on present missiles; and (4) large boosters (from 20 to 25 million pounds of thrust) can be safely fired from the Atlantic Missile Range.

Additional Studies and Research Grants.—NASA continued contract studies aimed at (1) finding a means of sealing the solid-propellant motor against the effects of the space environment; (2) developing test valves that can control the flow of the 5,000°–6,000° F. gases generated by modern solid propellants; and (3) determining whether the burning rate of a solid propellant can be controlled by irradiating its surface with high-intensity sound waves.

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In two university research grants, NASA studied the viscoelastic characteristics for materials used in solid motors (for instance, Fiberglass) and low-pressure combustion problems. The objective: To calculate the physical properties of propellant and motor materials before design.

Application of Solids and Solid Systems to NASA Missions.—NASA continued attempts to determine where solid propellants can best be applied in space missions. As part of this investigation, researchers studied the effect of the space environment on solid propellants and solid motors.

Coordination with the Department of Defense resulted in the establishment of basic large solid motor performance characteristics and proposals for program schedules and funding. The Department of Defense will fund and direct the motor programs; NASA will integrate the motors into lunar launch-vehicle stages.

A contract was let to study potential problems in the use of clustered large solid motors and the building of cluster structures. Another contract will cover comparative studies of the best materials for these huge chambers and will indicate what additional development is necessary.

Nuclear Propulsion Programs

As an even longer range follow-on propulsion possibility, the nuclear rocket program (joint NASA–AEC) should ultimately develop nuclear rocket systems for space exploration. When developed, nuclear rocket systems should provide the propulsion necessary for the extremely long space exploration efforts.

The nuclear rocket program (ROVER) consists of four segments—KIWI, NERVA, RIFT, and advanced technology. The KIWI project should produce a hydrogen-cooled nuclear reactor; NERVA should result in the first generation nuclear rocket engine, employing the KIWI reactor design; RIFT is expected to design, develop, fabricate, and flight-test a NERVA-powered vehicle as an upper stage for a Saturn-class launch vehicle; and the advanced technology effort will extend research and development leading to improved nuclear rocket engines.

In the KIWI project, research and development tests were proceeding at the Los Alamos Scientific Laboratory. During the preceding report period, the KIWI-B underwent first tests; these used gaseous hydrogen as the reactor coolant. In this current reporting period, researchers were preparing for further tests that would employ liquid hydogen as the coolant. (The tests began in July; they will be included in the next report.)

With NERVA, the contractors successfully completed the preliminary design phase (phase I) of the development effort. Subsequently, NASA and AEC put into effect (February 16, 1962) an interagency agreement to establish and operate the nuclear rocket development station at the Nevada test site. They also chose a contractor to manage construction of the station's facilities. (Of interest here: AEC started a program to qualify potential suppliers of reactor fuel elements; 11 different companies submitted proposals that are now being evaluated.)

For RIFT, NASA selected a prime contractor to design, develop, test and deliver the RIFT stages for static, dynamic, and flight tests. The contract was in the preliminary design phase at the close of the reporting period. (See fig. 5–1.)

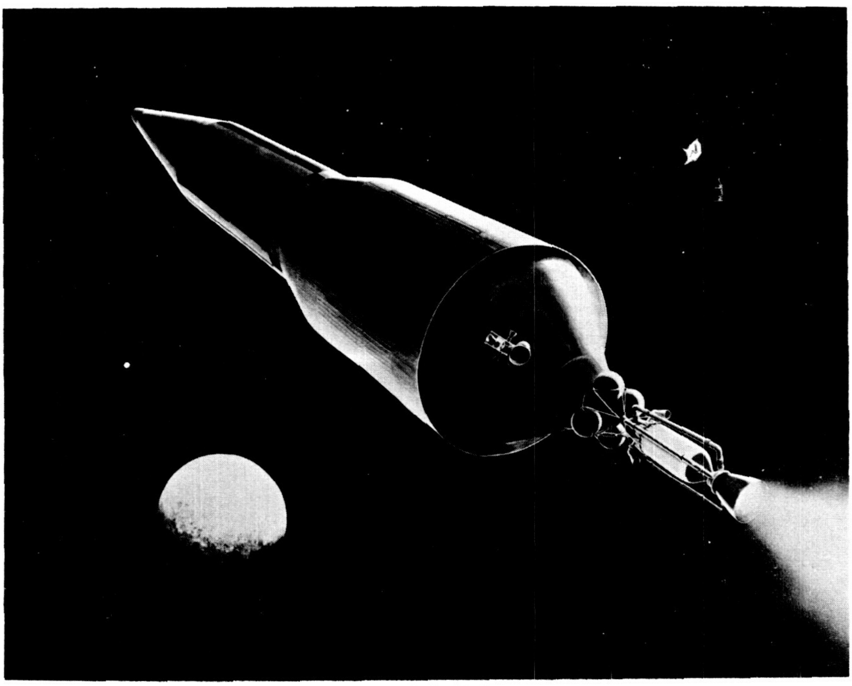

Figure 5–1. Artist's conception of a RIFT stage.

Extending farther into the future, the advanced technology program has as its objective the development of advanced nuclear rocket engines. Efforts are underway to provide improved and advanced versions of the reactor concept being used in KIWI-NERVA. This work relies extensively on KIWI technology and facilities.

NASA also continued seeking to advance the nuclear vehicle concept beyond the present RIFT design. This program includes mission analyses, material studies, and radiation effects studies.

Electric Propulsion Program

While NASA was pressing for achievements in its nuclear rocket program, it was also making headway in electric propulsion research. Based on the payload-to-initial-vehicle-weight ratio, an electric propulsion system is more efficient than other rocket systems for many space missions.

NASA's electric propulsion program has two goals: low-power systems (30 to 60 kw.) for attitude control, station keeping, and orbital transfer of satellites; and high-power systems (larger than 60 kw.) for interplanetary missions. In this program, NASA is working to develop electrothermal, electrostatic, and electromagnetic engines.

Electrothermal (Arc Jet) Engine.—A laboratory model of a 1-kw. flight engine was recently tested in the vacuum tank facility at NASA's Lewis Research Center. Continued work on this type of engine emphasizes an engine system design that would perform reliably while operating "on-off" for periods ranging from 3 months to 3 years. This engine could control the attitude and stabilization systems of satellites, including those designed for stationary orbits (24-hour orbits, synchronous with the earth's rotation). The engine could also lift small payloads (approximately 300 lbs.) from low elliptical earth orbits into the 24-hour orbit or perform other orbit transfers for increasing the versatility of a given satellite to satisfy a variety of requirements for scientific observations.

Through contracts, NASA has developed laboratory models of two different 30-kw. arc jet engine concepts; these models were ground-tested for 50–100 continuous hours without any apparent component deterioration. One model is a 30-kw. d.c. radiation-cooled arc jet engine; the other is a 30-kw. three-phase a.c., radiation-cooled engine. Both engine versions will operate with hydrogen or ammonia propellants, producing ½-lb. thrust.

Electrostatic (Ion) Engine.—NASA was also developing laboratory and flight models of two ion engines. (See fig. 5–2.) One produces about 0.002, the other about 0.007, pounds of thrust. Both will require approximately 1-kw. electric power, and will be used to correlate flight-test results and space-simulated ground-test results. They will also serve as a first step in developing 30-kw. and larger ion engines. Development efforts continue with both engines.

The 0.002-pound-thrust module of one of these, a cesium surface contact engine, has been successfully tested in an environmental

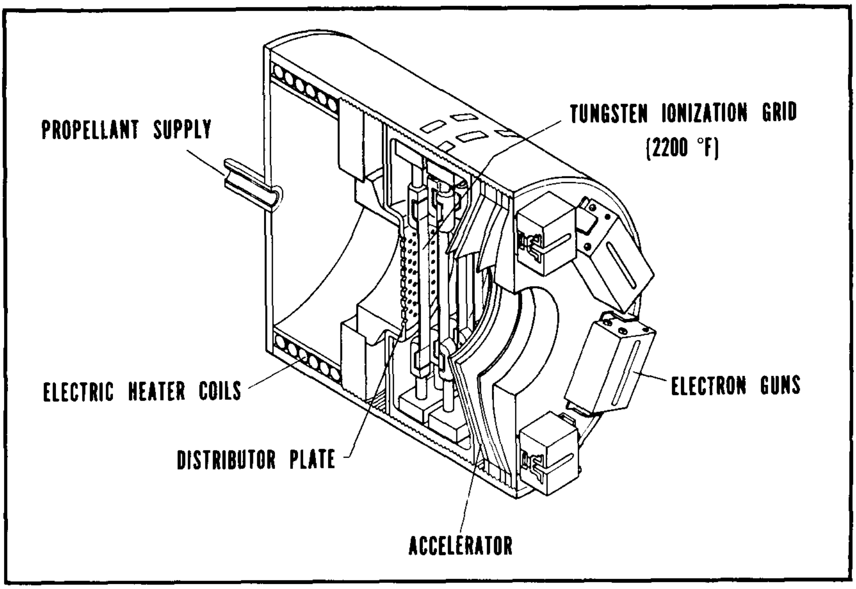

Figure 5–2. Cutaway model of ion rocket.

chamber and packaged for flight testing. Current investigation is seeking to determine a method of scaling the small module upward to a 30-kw. power level engine.

Development work also continued on the other ion engine (electron bombardment); this one uses mercury as a propellant. A module of this engine (0.006- to 0.007-lb. thrust) has been environmentally tested and packaged for flight tests.

Electromagnetic (Plasma) Engines.—NASA is sponsoring several investigations to determine the feasibility of various magnetohydrodynamic (MHD) techniques for producing propulsion in space vehicles. (For a description of the MHD concept, see NASA's fifth semiannual report to Congress, ch. 8.) The contractors engaged in these studies made measurements of plasma properties and are in the process of constructing test equipment for thrust or performance tests.

POWER GENERATION PROGRAMS ADVANCING

Paralleling its propulsion research, NASA is developing electrical power plants to operate onboard equipment and electrical propulsion systems of its satellites and space vehicles. Such development work is proceeding in two fields of effort: power systems that derive their energy from solar or chemical sources, and power systems that depend on nuclear energy.

Space Power Program (Solar or Chemical)

In its space power program, NASA was studying a broad range of power system configurations. The agency's investigations are concerned with both output (from a few watts to kilowatts) and operating time (from minutes to years). Specific matters being investigated include solar cells, batteries, fuel cells, thermionic devices, mechanical power conversion, and solar concentrators.

Solar cells, illustrated in figure 5–3, have proved to be vital to many NASA programs. However, they suffer damage in flight, and they are expensive. To reduce damage, NASA is studying the effects of proton and electron radiation damage to solar cells. The data from these studies are enabling the agency to know more about how these devices will perform in the Van Allen belts. The studies are also helping engineers to understand the cause of damages so they can improve the devices.

To reduce the cost of solar cell power supplies, NASA was engaged in designing a solar cell panel that uses parts of the structure to act as mirrors and focus additional light on each solar cell. Such a technique will cut in half the number of solar cells required per unit of power generated, yet add very little to the panel's weight.

Concurrently, NASA continued its program to develop a prototype solar-heated thermionic power system. The experimental thermionic diodes built under this program have demonstrated long life and uniform characteristics. The mirror or solar concentrator being developed for this type of system is very efficient.

Along another research avenue, NASA made progress in its space battery program. During this period, it established a pilot production line to produce a high-quality rechargeable battery. Four standard-sized batteries are now available; these batteries are being used in or are being considered for six DOD and NASA spacecraft.

NASA has also continued developing lighter weight, sealed silver-cadmium batteries. The first metal-enclosed, hermetically sealed version for space use was developed during this period. It was first used in the United Kingdom No. 1 satellite. A contractor is now conducting further life and performance tests on it.

In addition to these efforts, NASA neared complete development of a breadboard 250-watt hydrogen-oxygen fuel-cell system. This development contributed directly to the selection of fuel cells for the Apollo spacecraft.

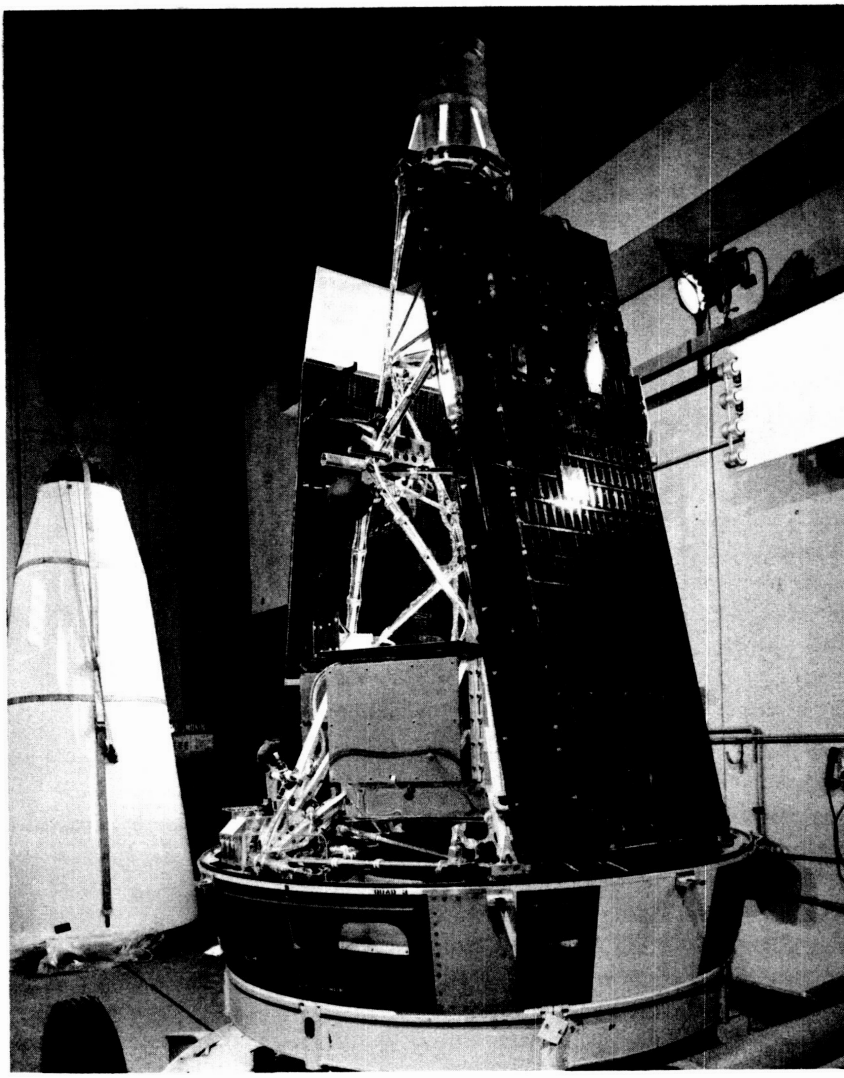

Figure 5–3. Solar cell panels of Mariner II folded in launch position.

Also during this period, work progressed on a rechargeable or regenerative hydrogen-oxygen fuel cell. NASA is now designing a prototype for possible use in an advanced planetary probe vehicle.

In still another project, NASA continued its efforts to develop the 3-kw. Sunflower turboelectric power system (fig. 5–4): A condenser designed to operate in "zero G" was successfully tested; the combined boiler and heat-storage unit demonstrated its ability to operate under simulated intermittent heat input conditions; tests on coating

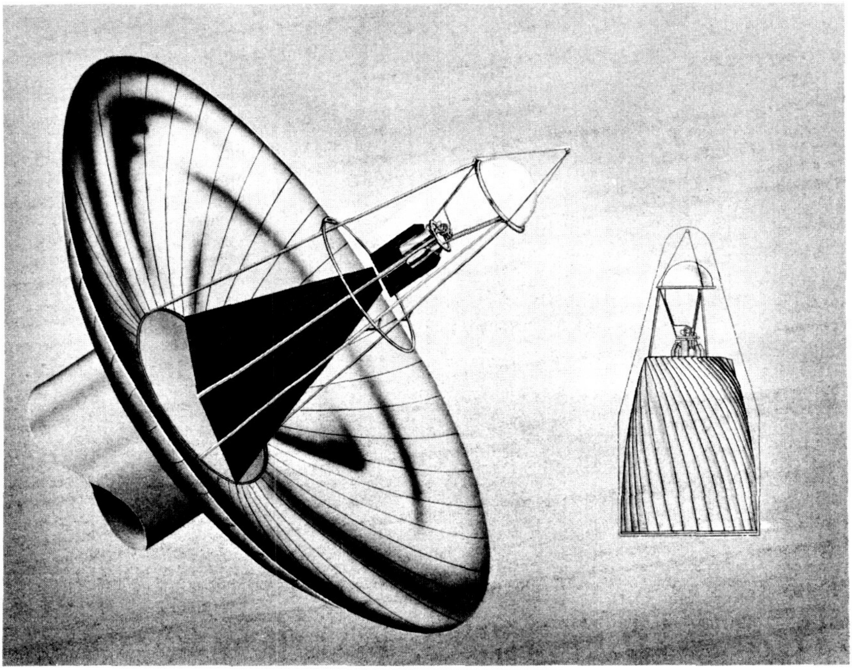

Figure 5–4. The Sunflower power system.

have identified some promising materials which may solve the problem of loss of hydrogen from the lithium hydride heat storage material; the turbo alternator unit completed several hundred hours of operation. The solar collector work has continued, and the technology of building large honeycomb petal type mirrors has progressed.

As this overall review of progress indicates, NASA was simultaneously moving in many directions to make certain that it develops chemical and solar-fed space power systems with the output level and life expectancy required for space missions. While it proceeded with these, it was also actively participating in joint NASA–AEC projects to develop nuclear electric power systems.

Nuclear Electric Power Systems

Through a NASA–AEC joint effort, nuclear electric power system projects continued to make progress. These projects are SNAP–8 (*S*ystem for *N*uclear *A*uxiliary *P*ower) and advanced nuclear electric power systems.

SNAP–8.—As previous reports have pointed out, the SNAP–8 nuclear electric generating system will provide power for electrical propulsion engines and onboard equipment when satellite or space station requirements reach 30-kw. or more.

During the period, engineers started power conversion system testing to obtain performance data and to verify component design. Problems in materials, boiling mercury heat transfer, and bearings were apparent. Improvements are necessary before endurance testing can be undertaken.

Engineers modified the boiler now in use and began design of a new one. Also, assembly of the first experimental SNAP–8 reactor continued after improvements in fabrication procedures reduced excessive hydrogen loss found in some fuel production elements.

Advanced Nuclear Electric Power Systems.—Beyond these two projects, NASA continued its program to obtain the basic data and technology required to construct lightweight (as low as 10 lbs. per kilowatt electrical) high-powered (megawatt or more) nuclear electric systems. A notable achievement was the start of operation of two boiling and condensing potassium heat transfer rigs.

The first to run was the 300-kw. loop (constructed primarily of an oxidation resistant superalloy). Operations began on February 26, 1962. Over 800 hours of test time have been accumulated to date on boiling potassium. (The maximum operating temperature of this rig is 1,800° F.)

Second to run was the 100-kw. test rig (constructed of a columbium alloy). It began operating on May 15. There have been 300 hours of all liquid shakedown operation to date. (Its maximum boiling temperature will be approximately 2,100° F.)

The data obtained from these rigs will apply to the boiler, condenser, and radiator components of advanced Rankine cycle electric power systems.

As this detailed review indicates, NASA's propulsion and power generation research efforts made further progress in the drive to provide advanced engines and electric power generation systems. Results to date support the conviction that these engines and plants will be available for individual missions, as needed.

Tracking Networks

During the report period, NASA expanded and improved its three networks of stations for tracking, commanding, and gathering information from spacecraft. Linked together and to NASA data centers by a communications chain, these networks—manned space flight, deep space, and satellite—perform functions essential to the success of all NASA flights. The Wallops Station facility was also improved.

MANNED SPACE FLIGHT NETWORK

The manned space flight network (MSFN), commonly referred to as the Mercury network, consists of 16 tracking and data acquisition stations. These afford a worldwide system for monitoring orbiting spacecraft within the latitudes of about 35° N. to 35° S. The Mercury, Gemini, and Apollo orbits will be within these latitudes. MSFN stations are located at Cape Canaveral (including installations at Grand Bahama and Grand Turk Islands); Bermuda; a ship in the Atlantic Ocean; Grand Canary Islands; Kano, Nigeria; Zanzibar; a ship in the Indian Ocean; Muchea and Woomera, Australia; Canton Island; Kauai Island, Hawaii; Point Arguello, Calif.; Guaymas, Mexico; White Sands, N. Mex.; Corpus Christi, Tex.; and Eglin Air Force Base, Fla.

MSFN stations are used to direct the spacecraft, to monitor the operations of the astronauts and the performance of the spacecraft, and to provide continuous impact prediction data. The network maintains nearly unbroken contact between the ground and the astronauts. During flights, almost continuous intercommunication takes place among the individual stations, the Goddard Space Flight Computer Center, and the Mercury Control Center at Cape Canaveral.

The network performed effectively during the Glenn MA–6 and Carpenter MA–7 Mercury flights. During the MA–6 flight, the network kept in touch with the astronaut and spacecraft almost without a break. It lost contact with Astronaut Carpenter at the end of the MA–7 flight because the extended reentry trajectory brought the spacecraft down beyond range of the network. This was the only prolonged interruption in communications during the flight. Otherwise, the network gave continuous and accurate impact prediction data and thus kept to a minimum the time required for the sea rescue.

NASA made progress in providing several MSFN stations with instrumentation required for future manned space flight missions. It installed command equipment on a telemetry ship to be located in the southeast Pacific Ocean. It began to extend the radar range capabilities at Bermuda and Hawaii, installed receiving equipment at the Guaymas Station, and continued work on a microwave link at the Bermuda Station.

DEEP SPACE NETWORK

The deep space network (also referred to as the deep space instrumentation facilities) monitors lunar and planetary probes. It consists of three stations—at Goldstone, Calif. (the master station of the network); Hartebeesthoek, Republic of South Africa; and Woomera, Australia.

During this report period, the Goldstone Station began to use commercial electrical power (5,000 kw.) and added a new 85-foot parobolic antenna and calibration tower. It also completed plans and the foundations for a small ranging antenna and for another 85-foot parabolic antenna. The Hartebeesthoek and Woomera Stations added equipment to improve their transmission of commands to spacecraft.

The network performed effectively during the lunar exploration attempts by Ranger 3, in January, and Ranger 4, in April.

SATELLITE NETWORK

NASA also improved its satellite network. Directed by Goddard Space Flight Center, this network has 13 operating stations—at Antofagasta, Chile; Blossom Point, Md.; College, Alaska; East Grand Fork, Minn.; Fort Myers, Fla.; Hartebeesthoek, Republic of South Africa; Lima, Peru; Mojave, Calif.; Quito, Ecuador; St. John's, Newfoundland; Santiago, Chile; Winfield, England; and Woomera, Australia.

NASA is constructing two additional stations equipped with large parabolic antennas. These are at Gilmore Greek, Alaska, and at Rosman, near Asheville, N.C. The Agency is conducting investigations for a third additional station—in the Far East.

The satellite network can track and acquire data from all NASA unmanned earth-orbiting satellites, including those in polar orbits, and can handle many vehicles in orbit at one time. Some of the network's stations can also determine the angular positions of satellites; these positions are used to compute orbital data for interpreting scientific information transmitted from the satellites.

Some stations are equipped with large data-acquisition antennas to handle the great volume of information telemetered back from the new, larger satellites. These are in remote areas with natural features (for example, bowl-shaped valleys surrounded by trees) that screen out noise.

Stations have been located in England, Alaska, Newfoundland, and Minnesota and equipped with antenna systems to strengthen NASA's capability to track satellites in polar and high inclination orbits. (A satellite in a polar orbit travels over both poles around the world and thus provides complete world coverage. A satellite in a high-inclination orbit travels in part over areas in the northern latitudes, such as Great Britain and Canada.)

NASA improved the network by installing command consoles (instrument control panels) at the 13 operating stations. With these consoles, the stations can handle more complex coding systems.

The Agency also progressed in its plans to provide each station with a self-tracking antenna that will automatically follow satellites. This provision will increase data-acquisition efficiency.

WALLOPS STATION FACILITY

The small self-contained facility at Wallops Station includes radar and telemetry antennas, communications lines, and a computer center. (See fig. 6–1.) This facility supports sounding rocket and geoprobe experiments and Scout research developmental flights. Its Mercury prototype tracking station makes tests of proposed changes and new developments in the system and is a training site for operating personnel. It is also the principal east coast receiving station for TIROS weather satellites.

The station improved its long-range S-band radar by installing a more powerful transmitter. Specifications were completed for a new amplifier which, when used with the transmitter, will make the radar capable of tracking a 6-inch target up to 200 miles.

Wallops also tied its launch systems into a master automatic programer to speed up countdown procedures and significantly increase the reliability of the launch support instrumentation.

Wallops Station acquired a 940-ton, 176-foot support ship, the *Range Recoverer*, from the Pacific Missile Range. The *Range Recoverer* is operated by the U.S. Navy's Military Sea Transportation Service but controlled for NASA missions by the Director, Wallops Station. Wallops is using the ship as a downrange telemetry station, surface surveillance station, and recovery vessel.

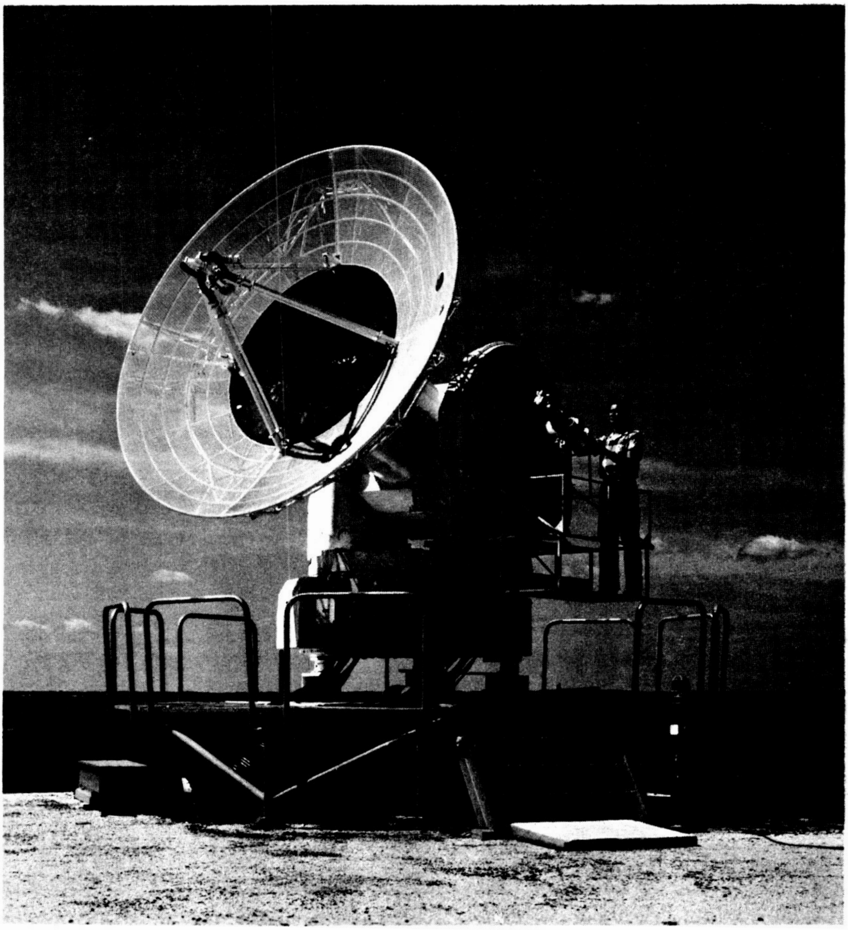

Figure 6–1. FPS–16 antenna at Wallops Island, Va.

Aeronautics and Space Research

NASA continued its progress in aeronautics and space research. The Agency and the Air Force decided to extend the research program of the X-15 rocket-powered airplane, which continued its series of tests and essentially reached its design altitude during a flight to 247,000 feet. In other aeronautics research, NASA constructed and flew a manned research paraglider to determine whether this type of vehicle can be used advantageously in the Gemini program, continued research and development on a variety of V/STOL aircraft and the supersonic commercial transport, and engaged in wind-tunnel and other studies of aircraft structures.

In space research, NASA undertook or continued flight and laboratory experiments to determine the effects of environmental factors on space vehicles, dealt with problems of spacecraft entering the atmospheres of Mars and Venus, worked on spacecraft structures, studied guidance and navigation requirements for lunar and planetary missions, and investigated spacecraft control and stabilization systems. NASA also conducted advanced space research on astrophysical, biomedical, and engineering instrumentation, data handling and processing systems, communications techniques and devices, and fluid physics.

These programs are adding considerably to the Nation's aeronautics and aerospace knowledge, skill, and resources. Through these programs NASA is improving advanced flight vehicles and supporting systems and is, therefore, preparing the way for flights to the moon and the planets.

AERONAUTICS RESEARCH

The X-15

During the first 3 months of 1962, the flight program to further explore the X-15's performance was held back by heavy rain and snow on the dry lakes near Edwards Air Force Base. NASA's Flight Research Center took this opportunity to make important engineering changes on the three X-15 experimental airplanes.

It installed auxiliary two-axis stability augmentation system units on X-15 No.'s 1 and 2. The pilot can energize these units manually or they can be engaged automatically should the primary stability augmentation system fail during the aircraft's reentry from high altitude As a result, a potential hazard was removed. In addition, the installation of a pressure-sensing unit to supplement the standard temperature-sensing control eliminated pressurization failures experienced in several previous X–15 flights.

After these modifications had been made and tested, NASA Pilot Joseph A. Walker on April 30 achieved the second major milestone in the X–15 program by flying the aircraft to an altitude of approximately 247,000 feet (almost 47 miles). Besides essentially reaching the design altitude, the flight obtained data on the use of reaction jet controls at altitudes near 250,000 feet, aerodynamic heating during reentry at high angle of attack, and recovery from extreme altitudes.

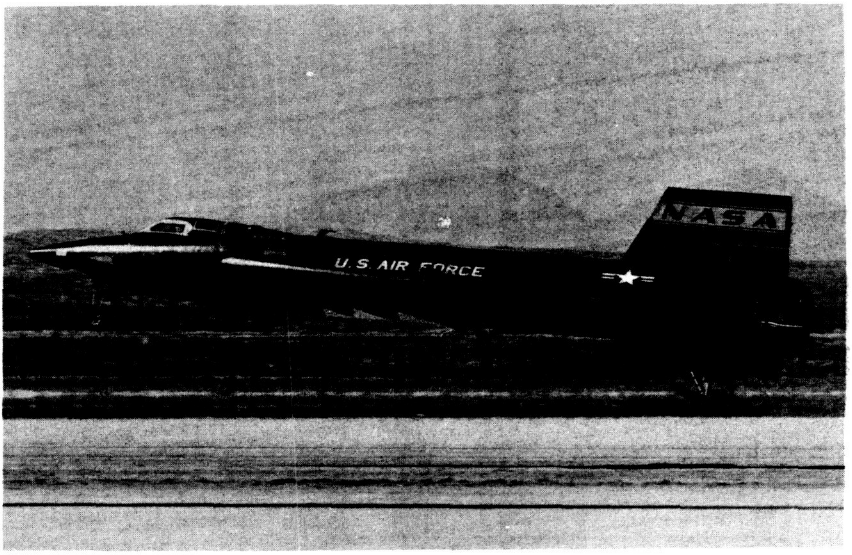

Figure 7–1. The X–15 research airplane.

NASA also conducted studies on the adaptive flight control system of the X–15 No. 3. This system is designed, through the blending of aerodynamic and reaction controls, to control and stabilize the vehicle throughout the aerodynamic and ballistic regimes. NASA conducted flight tests to obtain system performance design criteria, and data required for adaptive flight controls of future aerospace vehicles.

The Paraglider

Results of wind-tunnel and free-flight tests indicated that the paraglider (a flexible-winged, kite-like vehicle shown on pp. 88 and 89) may be used as a recovery device for space vehicles components such as capsules and boosters. With weight and volume similar to those of the parachute, the paraglider might offer a maneuvering capability, low landing speed, and a landing with near-zero vertical velocity.

NASA's Flight Research Center continued experiments with a research paraglider (PARESEV I—*pa*raglider *res*earch *v*ehicle) it constructed. It is attempting to determine whether this type of vehicle can be used to soft land the Gemini two-man spacecraft. Unlike other paragliders, this research vehicle (like a conventional glider) is manned, unpowered, and towed aloft for release.

The Paresev I program, which is on flight status, progressed satisfactorily. "Ground-tow" flights were made to 100 feet with 1,000 feet of towline, followed by flares and landings after release from the towline. As a result of these flights, the pilot developed a good "feel" for the aircraft.

After the ground tows, four aerial tows behind a light aircraft were made to a maximum altitude of 2,200 feet. After it had been released at this altitude, the pilot was able to control the paraglider easily in the subsequent glide and to perform flared landings with very low rates of descent.

The test did show, however, that the vehicle control system required modification. As a result, the original rigid control linkage was replaced by a cable-and pulley system. The first flight with the modified system took place in May.

Langley Research Center also conducted wind-tunnel work on the paraglider. The objective: to achieve a higher aspect ratio and performance for this vehicle.

V/STOL Aircraft

NASA intensified its efforts to gain greater technical knowledge for the design of V/STOL (vertical or short takeoff and landing) aircraft. It continued to explore many V/STOL approaches and concepts, including tilt rotor, deflected slipstream, tilt wing (see fig. 7–3), tilt duct, and fan-in-wing aircraft. It investigated the flying qualities of test-bed aircraft (utilizing the first three of these concepts), helicopters, and a STOL airplane.

The main areas of helicopter research were concerned with improving flying-quality characteristics to aid in achieving the capability for all-weather operation. Variable-stability equipment was added to a large, modern twin-turbine helicopter, the Vertol YHC–1A, enabling wide variation in flying characteristics. The objective: to study the factors affecting operation in the transition from the steep approach to vertical touchdown.

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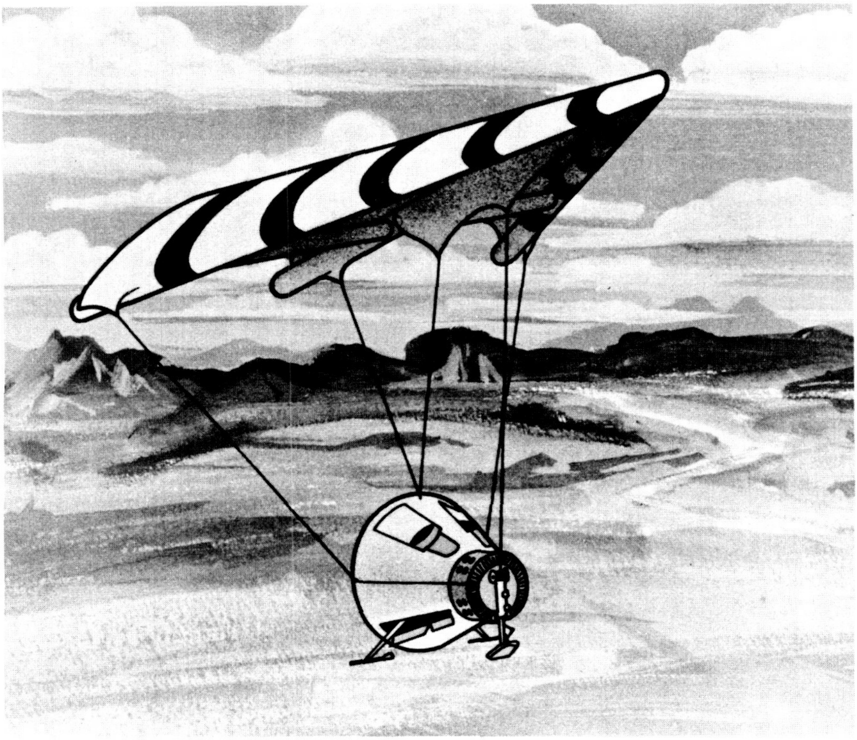

Figure 7–2A. Paraglider in full deployment.

In another recently initiated Langley helicopter program, studies were started to investigate the aerodynamics, structural loads, rotor dynamics, and flying qualities of the so-called rigid or nonarticulated rotor concept. This concept, which eliminates the flap and lag hinges of present-day operational rotors, promises major improvements in flying and handling qualities, in addition to simplicity of construction and greatly reduced hub drag.

Extensive investigation of the tilt-wing VTOL concept continued. In addition to the flying-quality studies of the Vertol VZ–2 test bed, wind-tunnel aerodynamic studies of large-scale general research models were conducted at Langley and Ames.

Particular emphasis was given at Ames to the lift-fan concept. The aerodynamic characteristics of a large fan-in-wing model were investigated (1) as a followup to a fan-in-fuselage model tested previously and (2) in preparation for planned tests of a model of the General Electric-Ryan XV5A fan-in-wing VTOL airplane.

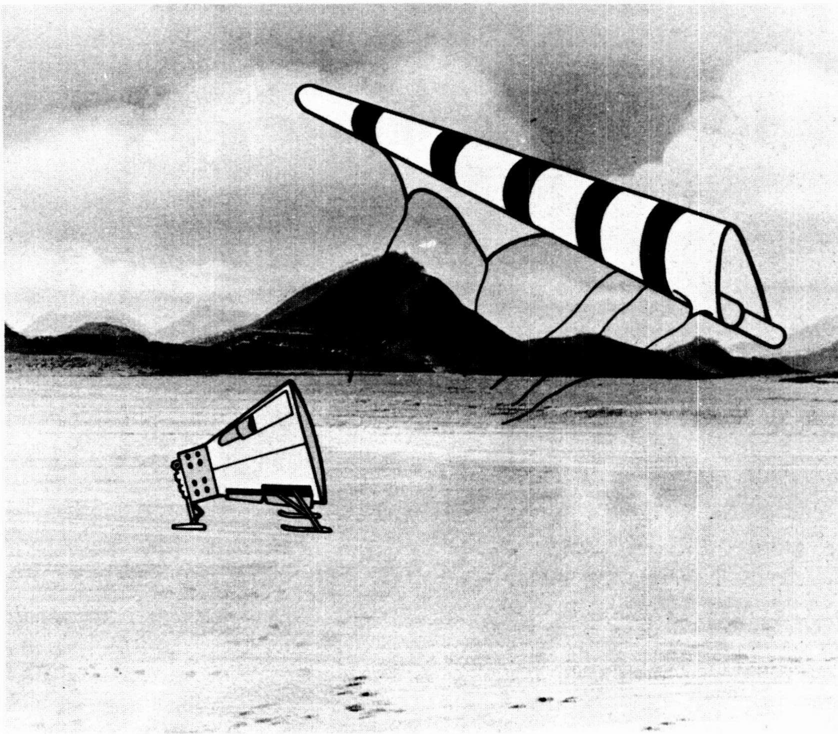

Figure 7–2B. Paraglider during ejection of wing.

The Langley and Ames Centers gave increased attention to wind-tunnel study of the tilt-duct concept to be used in the Bell X–22 airplane.

Stability, control, and handling-quality requirements for V/STOL aircraft were studied with the variable-stability helicopter, the Bell variable-stability deflected-jet VTOL airplane, and special ground-based simulators at Ames and Langley. Problem areas simulated included low engine thrust to airplane weight ratio, near-zero vertical velocity damping, poor engine response characteristics, and ground effect.

The Supersonic Commercial Transport

The Ames and Langley Research Centers continued work on the supersonic transport that NASA, the Department of Defense, and the Federal Aviation Agency are studying. Ames researchers completed wind-tunnel tests of a large supersonic transport model's stability and control. These tests indicated that wingtip extensions improved the maximum lift-drag ratio about 13 percent and shifted the aerodynamic center in the stabilizing direction.

Langley Research Center investigated various supersonic transport configurations in an extensive research program to provide basic information for the design of a modern high-speed transport. It tested proposed models in its wind tunnels. One model, the SCAT–3 (see fig. 7–4), was used to determine performance and stability characteristics through the complete speed range to mach 3 (about 2,000 m.p.h. at high altitude). Another model, the SCAT–4 (see fig. 7–5), was designed to reduce drag to a minimum at speeds between two and three times sonic velocity.

Other extensive wind-tunnel studies were continued to gain a better understanding of the use of variable-sweep wings in the design of the supersonic transport.

NASA's Flight Research Center used the F–100C variable-stability airplane to simulate various handling qualities required for supersonic transports.

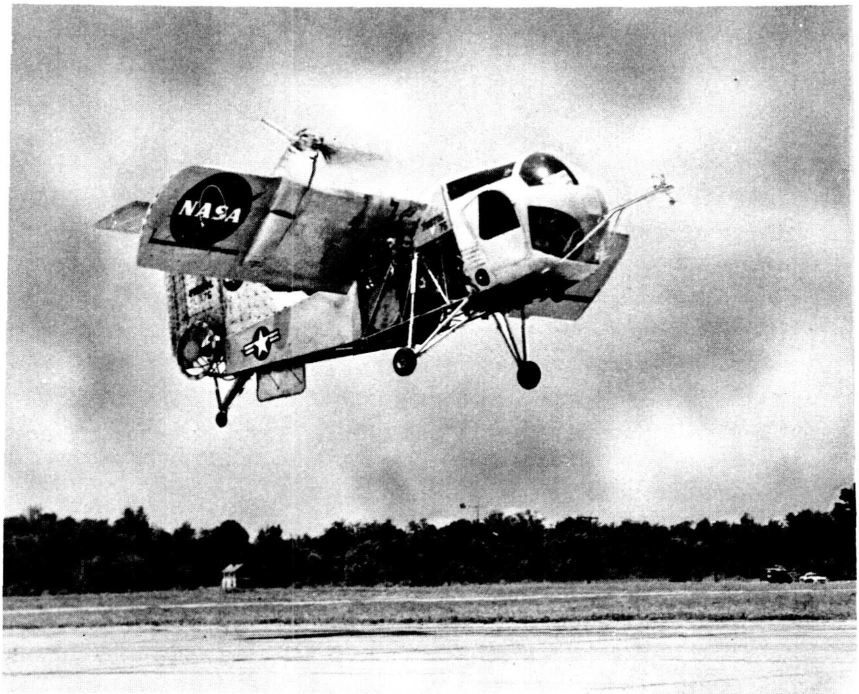

Figure 7–3. Tilt-wing test-bed configuration (Langley Research Center, Va.).

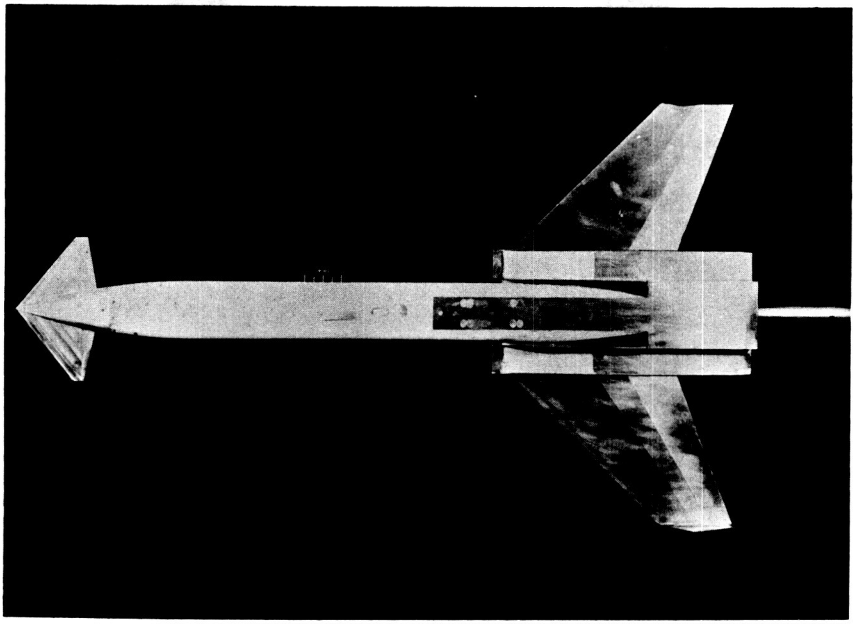

Figure 7–4. Supersonic air transport (SCAT–3), model.

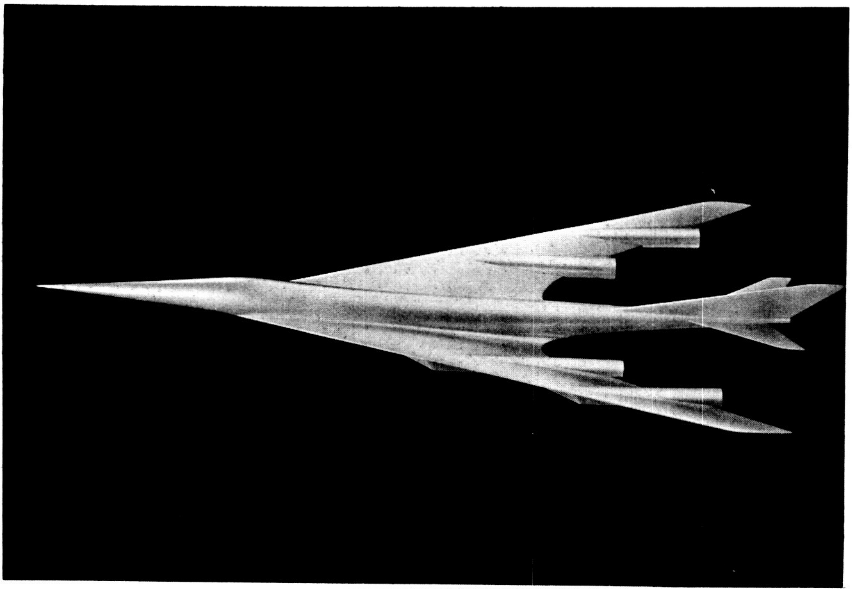

Figure 7–5. Supersonic air transport (SCAT–4), model.

Aircraft Structures

The Langley Research Center progressed in developing the equipment and techniques required to conduct research on gust response of aircraft by use of wind tunnels. The equipment will produce flow variations in the wind-tunnel airstream, simulating flight through atmospheric turbulence. The resultant forces and motions produced on structurally scaled wind-tunnel models will afford means for evaluating current methods of gust response analysis.

SPACE RESEARCH

Flight Experiments

NASA conducted experimental flights to study the effects on spacecraft of wind profile (steady windspeed over a large altitude range), the meteoroid hazard, and aerodynamic heating. NASA also flight-tested the effects of weightlessness on fuels and developed a standardized recovery package.

Effect of Wind Profile.—One of the most important factors to be considered in launch-vehicle design is the effect of the wind profile, including wind shear and turbulence, on the structure of the vehicle. In working on this problem, NASA researchers used small sounding rockets to lay smoke trails which can be simultaneously photographed by cameras located at opposite ends of a baseline. These photographs, when analyzed, yield accurate measurements of wind shear and turbulence required for the structural design of launch vehicles.

The Meteoroid Hazard.—NASA continued work on a broad program to determine the material required for protection against meteoroids and to provide conclusive information on meteoroid penetration rates in spacecraft material.

The first spacecraft used in the program, the S–55 micrometeoroid satellite (fig. 7–6), was exposed to near-earth space. No meteoroids penetrated the spacecraft in 2½ days of exposure. On the basis of one model of the meteoroid hazard, several penetrations had been expected. Another meteoroid satellite flight was scheduled to verify these limited data.

This program also provides for a series of meteor-simultation experiments to measure the luminosity of known materials entering the atmosphere. A six-stage rocket vehicle is used in this work. A light gas gun containing a dime-size pellet is mounted on the last stage. At burnout of this stage the gun is fired, accelerating the pellet to meteoric velocities.

Figure 7–8. Lewis Research Center, Cleveland, Ohio.

study crew arrangement, task allocation, window sizes and location, etc.

Universities and research organizations conducted NASA-sponsored studies on configurations of flight-control systems. The objective: Systems capable of causing the vehicle to achieve the desired flight path in a minimum of time, with minimum energy, control force and structural loads. Early results of this work were applied to perfecting the trajectory of a lunar vehicle.

Astrophysical, Biomedical, and Engineering Instrumentation

Study of the physical properties of space, the earth, and other celestial bodies and their atmospheres requires new or improved astrophysical recording and measuring devices.

NASA did significant work on devices for detecting and counting micrometeoroids. It designed a pressurized cell in which a metal diaphragm closes a miniature switch when a pressure loss occurs.

NASA tested another method of detecting and counting; this involves the use of alternate layers of metal and plastic. When a particle strikes the plastic, the resulting atomic disturbances cause an electric current to flow through the assembly. Appropriate electrical circuits can determine speeds and total numbers of particles.

NASA also studied a micrometeoroid detector in which light flashes when high-speed particles strike resisting bodies. It originated a device that measures the "push" imparted by the striking particles.

The Agency also worked on small calorimeters which directly measure the extremely high heating rates and total heats experienced at reentry from a lunar mission. In related work, it studied the precise measurement of low pressure during reentry. For these studies, NASA researchers developed a device that measures pressure over a wide range.

In biomedical instrumentation, Ames Research Center began a program to design microminiaturized biological sensors and transmitters which use little power, do not disturb wearers, and free men or test animals from the inconvenience and danger of attached wires.

Three Agency centers are active in engineering instrumentation research and development. Lewis Research Center began constructing reentry simulation facilities and devised new techniques for calibrating pressure-measurement instrumentation. Ames Research Center undertook to develop microminiaturized, extremely rugged devices to measure accelerations, pressures, and temperatures associated with free-flight models subjected to launching stresses up to 1 million g's. And Marshall Space Flight Center began (1) devel-

Although these promise radical advances in technology for future missions, NASA continued its improvement of more conventional devices, such as gas-bearing gyros, to meet immediate mission requirements.

Rendezvous Technology.—Electronic guidance systems planned for use with Gemini and the early Apollo missions are limited to existing state-of-the-art techniques because of schedules established for these missions. NASA is studying improved ways to mechanize these systems. During the period, it progressed in industry surveys of rendezvous techniques, the total rendezvous problem, and various systems to establish sensor requirements and their best performance parameters. The goal: a system for Apollo and post-Apollo missions.

Interplanetary Trajectories.—NASA continued its studies of lunar mission trajectories, particularly for return to earth from lunar surface launch or injection from close lunar orbit. The agency increased its work on interplanetary trajectories. It completed trajectory studies for Venus and Mars fly-by missions. It began studies on problems associated with planetary entry, descent from planetary orbits, and the return of a spacecraft from a planet to earth. It also considered trajectories for using the continuous thrust of electrical propulsion systems under development.

Control and Stabilization

In its research on ways to control and stabilize spacecraft, NASA conducted studies on the control of satellite vehicles, simulation and flight-control display technology, and automatic flight-control configurations.

Ames Research Center designed and tested a flight-control system that automatically points satellite vehicles. It conducted further work to determine how this system can be adapted to a manned vehicle for possible application to the manned lunar flight program.

Using an inflated radome simulator, Langley Research Center simulated rendezvous of two orbital bodies under manual flight control. It determined minimum instrumentation requirements for midcourse control.

Langley and Ames Research Centers conducted studies of displays for controlling flight paths during earth reentry. They investigated fixed-reference and pilot-determined trajectories and developed several feasible guidance and control methods.

Ames investigated Apollo crew station design variables—such as instrument displays, controls, and restraint equipment—to determine the influence of internal arrangement on crew performance. It constructed a mockup of the Apollo capsule; this mockup is used to which can be folded for a launching package and extended when in orbit.

Guidance and Navigation Systems

In its studies of spacecraft guidance and navigation, NASA concerned itself principally with systems for manned lunar and unmanned lunar and planetary missions.

Midcourse Guidance Procedures for the Manned Lunar Mission.—NASA progressed in its program to develop onboard midcourse guidance procedures for a manned lunar vehicle. It developed (1) a technique for using onboard optical measurements of the earth and moon, along with predictions of future position and velocity of the lunar vehicle, and (2) a guidance law based on a specified time of arrival at destination. These determine the necessary velocity corrections to minimize the errors at perilune and perigee (the orbital points nearest the moon and earth). The agency also continued work on incorporating ground tracking data into the onboard computation system and perfecting the guidance system.

NASA also studied an emergency manual midcourse guidance procedure for the return from the moon. This procedure could be utilized if key elements of the complex onboard electronic equipment failed.

Horizon Definition and Sensing.—Langley Research Center began a rocket flight test program to determine what the horizon looks like to sensors operating at various wavelengths (visible, infrared, ultraviolet, etc.), and what types of sensors can determine the horizon most accurately under the varying conditions of the day-night cycle, cloud cover, topography, and latitude.

First flight results indicated that sensors other than the "near infrared" types now used may offer improved performance in horizon-sensing equipment.

Gyros and Accelerometers.—NASA continued research on equipment that will provide accurate and reliable guidance and navigation of future launch vehicles and spacecraft. It worked on gyros and accelerometers for inertial guidance; these are to be used for launch, terminal, and reentry guidance and for midcourse corrections. NASA concentrated on electrostatic gyros and accelerometers in which mechanically supported rotors and acceleration-sensing masses are—to eliminate mechanical function and wear—replaced by rotors and sensing masses supported by electric fields.

The agency made feasibility models of these devices and proceeded to test them. It continued to work on improvements to the models. NASA also worked on cryogenic gyros and accelerometers.

Data from two meteors were studied through analysis of their luminosity and the dynamics of their flight through the atmosphere. By photographing the meteors from several points with continuously running cameras, Ames scientists were able to predict the velocity, the deceleration history, the mass, and approximate landing point of the meteors. They obtained the luminous-intensity history of the meteors from spectrographic information and the known response of the film. Using this information, they can evaluate the heat transfer to the meteor. This method holds good promise of predicting, at reasonable cost and effort, the heating characteristics of bodies traveling at speeds far above those now available in the laboratory.

Ames and Langley Research Centers and the Jet Propulsion Laboratory jointly engaged in developing shapes for spacecraft designed to enter the atmospheres of Mars and Venus. They studied the design and stability of models at high mach numbers. Their studies have covered a wide range of configurations and flight conditions. The objective: to develop spacecraft designs that are able to withstand the intense heating of entry, yet are able to serve as inherently stable platforms for the complex instrumentation necessary for planetary surface and atmospheric exploration.

Knowledge of the airflow around blunt bodies at hypersonic speed is important in understanding the stability and heating of spacecraft. Ames Research Center continued studies on the flow field characteristics of various configurations, utilizing a computational scheme originated by two of its scientists. The purpose: to provide the spacecraft designer with the detailed information necessary to calculate both the heating and stability of the spacecraft.

Spacecraft Structures

Ames Research Center progressed in studies of the effect on space vehicles of buffet (fluctuating pressures on the spacecraft structure). Ames also investigated the instabilities of nose shapes and the results of surface winds on a launch vehicle as it sits on the pad.

Langley Research Center built a model of the Saturn SA–1 and then submitted it to a dynamic test. The purpose: to determine the natural frequencies and mode shapes (the bending of the vehicle as it vibrates) of the full-scale vehicle in a simulated airborne condition. Comparisons can then be made with theoretically determined results that are used in the vehicle design. Langley's test results were compared with full-scale test results obtained by Marshall Space Flight Center.

Langley Research Center also conducted studies of materials in improved forms and combinations for constructing a space laboratory

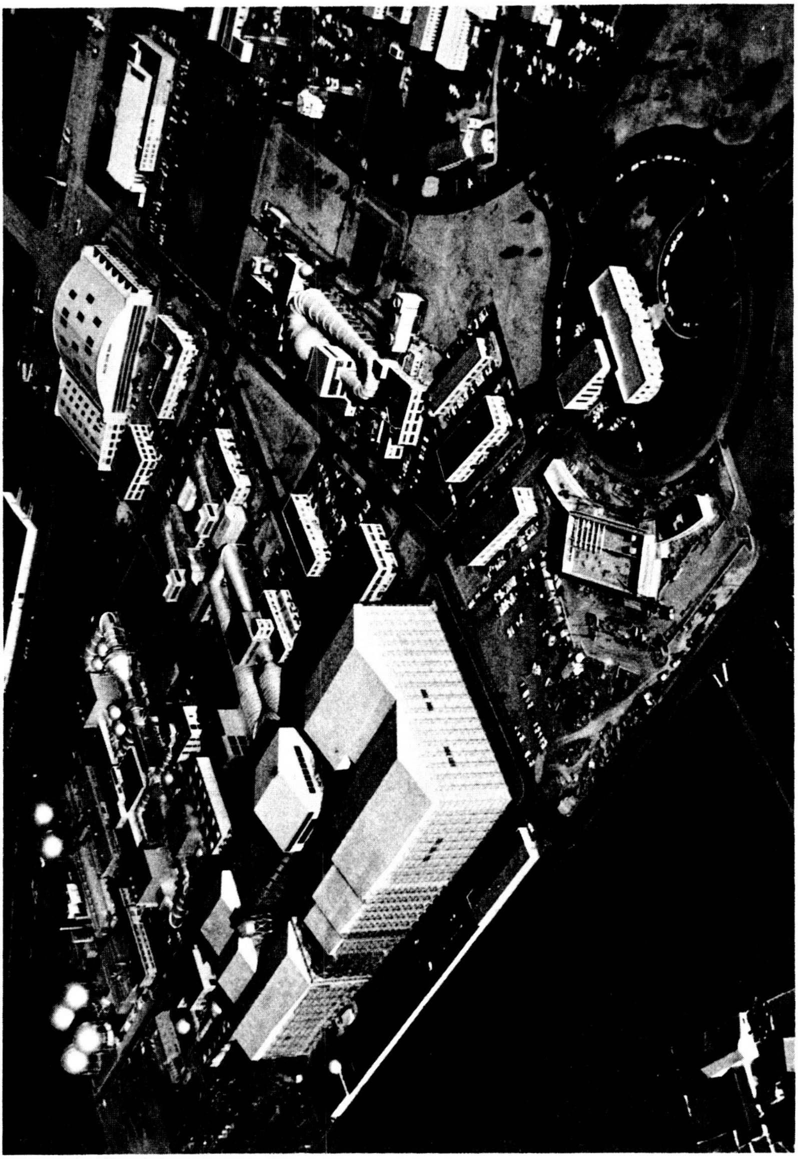

Figure 7–7. Ames Research Center, Moffett Field, Calif.

Spacecraft Laboratory Experiments

NASA laboratory researchers continued their work on the effect of environmental factors on space vehicles. They concentrated their research on solar temperature control, extreme vacuum conditions in space, and high-energy radiation effects and shielding.

The Langley Research Center devised a method for maintaining the temperature of a 12-foot-in-diameter inflatable satellite (Explorer IX) within acceptable values. Langley determined that proper temperature control can be obtained in sunlight when the satellite is in orbit by a special coating applied in a calculated percentage to the balloon's outside surface.

NASA continues its efforts to solve the problem of low pressure in space. Normal liquid and semisolid grease lubricants on spacecraft equipment exposed to the space vacuum evaporate rapidly. Without sufficient lubrication, parts are affected by friction and wear.

NASA undertook an investigation in a specially designed laboratory vacuum chamber. Test results indicated that (1) thin metallic films have considerable promise when used as lubricants in a low-pressure environment and (2) pure gold plating is not as effective as gold with additives.

High-energy charged-particle radiation in space may adversely influence the operation of sensitive spacecraft components and necessitate the use of large amounts of shielding to protect man.

Langley Research Center technicians, using various accelerator facilities across the country, irradiated a number of solid-state devices. They found that low-frequency transistors and solar cells are significantly degraded after exposure to proton fluxes roughly equivalent to 2 months in the Van Allen belts.

Marshall Space Flight Center continued studies of shielding against charged-particle radiation. It developed computer programs for calculating secondary radiation production in shields. It began experimental work in this area as a check on the analytical techniques.

Problems of Spacecraft Entering the Atmospheres of Mars and Venus

NASA is investigating aerodynamic heating that spacecraft will encounter in the atmospheres of Mars and Venus and their performance in these atmospheres.

Work conducted at Ames indicated that much useful information on atmospheric entry at higher speeds can be obtained by observing natural meteors. These enter the atmosphere at 25,000 to 160,000 m.p.h.

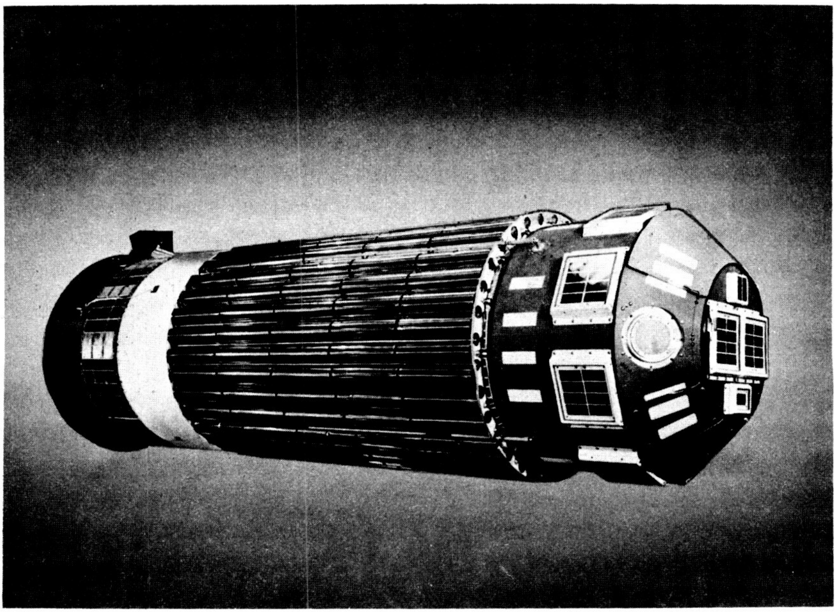

Figure 7–6. Micrometeoroid satellite (S–55).

During the report period, two flights fired simulated meteors. In the first flight the pellet entered the atmosphere at a velocity of about 33,000 ft./sec.; in the second flight, at about 47,000 ft./sec. Both flights yielded good information on the luminosity of the entering pellet.

Aerodynamic Heating.—NASA continued its flight program to determine aerodynamic heating during earth entry at satellite speed and during reentry from lunar and planetary missions.

Effects of Weightlessness on Fuels.—NASA continued its program to develop techniques to keep liquid fuel at a desired location when a spacecraft is in a zero gravity (weightless) condition—after it leaves the earth and its propulsion unit shuts down.

The agency worked on developing techniques by which the surface tension of the fluid is the dominating force in holding the fuel in the desired location in specially shaped fuel tanks. It also studied heat transfer to extremely cold fuels under conditions of zero gravity.

Standardized Recovery Package.—NASA developed and flight-tested several small containers having complete recovery equipment. These containers make possible the recovery of camera film and other similar sources of data obtained during the early launch phase of spacecraft and sounding rockets.

opment of a device to measure flow rates of fuels and (2) design of facilities required to measure extremely high thrusts.

Data Handling and Processing Systems

NASA conducted important research and development studies to meet its requirements for (1) launch site automation that will result in accurate checkout and countdown of spacecraft, (2) ground data-processing systems for advanced flights, and (3) advanced computing devices with higher speeds and reliability.

The Marshall Space Flight Center developed advanced techniques for launch site checkout and countdown of space vehicles. It constructed a prototype unit now undergoing evaluation.

This system (1) analyzes thousands of measurements per second to indicate the vehicle's readiness for launch; (2) monitors and updates the vehicle's intelligence system to take into account the relative motion between the earth launch site and a selected space target; and (3) performs a complex analysis of running occurrences as they take place.

The overall effect is to enable a complicated vehicle such as the Advanced Saturn to be checked with minimum error and loss of time and therefore with virtual assurance of a successful launch.

Goddard Space Flight Center began a computer prelaunch checkout of scientific experiments carried on the Orbiting Geophysical Observatory (OGO). At the same time, it evaluated OGO checkout procedures.

During the period, the agency completed its first NASA-wide technical survey of ground data-processing systems as a preliminary to setting up plans for future needs.

Jet Propulsion Laboratory began development of a real-time automatic-computing operating and control system required for the Ranger, Mariner, and Surveyor projects.

Several NASA centers have undertaken to improve computer or data-processing system components, circuits, and input-output and storage devices. Their objectives: higher operating speeds and packing densities, lower weights and power consumption, and much higher reliability.

Goddard Space Flight Center furnished an advanced telemetry encoding system for the successful joint United Kingdom-United States Ariel I satellite. It also developed special counters which compress data in various ways.

Jet Propulsion Laboratory worked on digital computer programs which process pictures transmitted by television systems. It demonstrated that certain persistent defects in the pictures can be removed.

Lewis Research Center designed and constructed a mockup of "micropower" (extremely low power) transistor circuits. It is constructing experimental analog-to-digital converters using these circuits. This Center also developed a digital data-handling system for use with micrometeoroid sensing equipment.

Communications Techniques and Devices

In its search for improved ways of transmitting sound and visual communications over vast distances, NASA conducted research on lasers (devices which transmit intense beams of light), microelectronics (the art of conducting very small electronic circuit elements), and methods of eliminating plasma sheath interference with radio transmission.

The Agency also planned a special study on a space communications system that would operate over distances of the order of 50 million miles and would be capable of transmitting voice or TV pictures.

At Wallops Station, NASA researchers conducted two reentry experiment flight tests on the problem of blackout of radio signals when a spacecraft enters the atmosphere. One flight was made to determine, by measurement, the physical characteristics of the plasma; the other, to determine how an artificial magnetic field affects the ability of radio waves to penetrate plasma sheath.

Fluid Physics

NASA continued its investigations of fluid physics, including electric drag on satellites, gases simulating the atmosphere of Mars, and plasma accelerators.

Ames Research Center worked on the effects of electrical charges on the drag of orbiting satellites; these satellites acquire an electrical charge as they move through the rarefied upper atmosphere at high speeds.

In a related theoretical study, Langley Research Center investigated the drag forces on a spherical body moving with satellite velocity in the earth's upper atmosphere. It formulated satisfactory physical models and calculated drags.

Ames researchers measured the radiation properties of gases simulating the atmosphere of Mars.

Langley and Lewis Research Centers investigated plasma accelerators. These offer the possibility of providing thrust for space applications and sources of high-velocity gas for research purposes.

Lewis Research Center worked on the so-called "traveling wave plasma engine", in which high-frequency electric fields are produced. The center constructed a high-speed-impulse engine of this type.

Life Science Programs

NASA has expanded its bioscience programs (Office of Space Sciences) to enable research in human engineering and in the biological sciences to keep pace with the Nation's rapidly advancing space technology. Further, the Agency announced in June the establishment of a biotechnology and human research program in the Office of Advanced Research and Technology to provide more data on man's ability to adjust to the stresses of outer space. Such information will serve as the basis for designing future spacecraft.

The Ames Research Center, Mountain View, Calif., will play a key role in the research and development projects of this new program, as the Center continues to complement the work of bioscience programs and aerospace medicine (Office of Manned Space Flight).

Continuing expansion in aerospace medicine and biology during the period of this report is evident from the brief accounts of progress in NASA's various life science programs which follow.

AEROSPACE MEDICINE

The Aerospace Medicine Division of NASA's Office of Manned Space Flight is charged with insuring the safety, health, and reliability of astronauts and ground crews preparing for and during manned space flight missions. Biomedical scientists develop and test atmosphere and waste-control systems, pressure suits, crew equipment, and survival and recovery aids, and investigate means of providing food and water supplies.

In the operational medical support of flight missions these scientists select the crews—caring for them from the time of their designation for flight assignments. They also provide flight and ground instrumentation, as well as trained medical personnel, for medical monitoring of crews from the ground during flights.

Further, they make certain that competent medical care is available in recovery areas around the world, and they collect and analyze medical data to add to the knowledge of the effects of space travel on man for use in planning future missions.

The following summary of the medical history of the Nation's first manned orbital flight and of NASA's program in the field of aero-

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space medicine exemplifies the work carried on by the Agency's Aerospace Medicine specialists.

The orbital flights of Astronauts Glenn and Carpenter in the spring of 1962 showed that man can perform effectively for extended periods of time in the hostile space environment; they also provided life scientists with an opportunity to study the effects of prolonged weightlessness and of launch and reentry accelerations. Earlier flights of Project Mercury furnished biomedical scientists with invaluable information but were too brief to permit an adequate assessment of the physiological effects of the weightless state.

Medical histories of the Glenn and Carpenter flights have been published.[1] Data from the first orbital flight revealed several significant points.

Glenn experienced no unusual changes in blood pressure, heart rate, respiration, or bodily temperature, during weightlessness—remaining essentially normal from a medical standpoint before, during, and after the flight.

Isolation and confinement did not interfere with his active work schedule while in space. He neither became nauseated nor vomited—instead, he described a "stomach awareness" while the capsule was on the water during the 20-minute period before recovery. However, this sensation cleared up quickly. It was probably due to a combination of factors—increased environmental temperature after the flight, mild dehydration of the astronaut, and the bobbing motion of the spacecraft on the sea. The mild dehydration resulted from overheating experienced just before landing and while on the water awaiting pickup.

Astronaut Glenn lost only slightly more weight than he had during a three-orbit simulated flight on a centrifuge. At all times his voice reports were clear, coherent, and confident. His hearing was unimpaired, and he experienced no difficulty in seeing nor in distinguishing between colors.

The first U.S. manned orbital flight added greatly to information on human responses to the space environment. In addition to data supplied by a variety of instruments, the pilot provided his invaluable observations on general body sensations. He commented on eating (malted milk tablets and a tube of applesauce), urinating, and on performing various other planned tasks in space, as well as on piloting

[1] "Results of the First United States Manned Orbital Space Flight, February 20, 1962," and "Results of the Second United States Manned Orbital Space Flight, May 24, 1962," Manned Spacecraft Center, National Aeronautics and Space Administration, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Illus., 204 pp. and 107 pp., prices $1.25 and 65 cents, respectively.

the spacecraft. Rapid head-turning exercises, performed to determine if they would produce nausea, failed to cause this sensation.

The impressive medical data gathered from the Glenn flight are indications of the complexity of the medical problems of manned space flight. Other NASA research programs are probing into many of these problems.

Studies are being made of the long-term effects of pure oxygen on men working in a simulated outer space environment. Six men will be tested in this unprecedented experiment—another six serving as control subjects.

A hazard to space travel is the micrometeorite bombardment of space vehicles. Investigating methods of shielding the astronaut against this danger, experimenters are firing aluminum-shaped charges of micrometeorite size into test chambers housing rats.

Another danger in manned space flight is the relatively undefined threat of space radiation hazards. To investigate and guard against these dangers that can come from many sources such as the sun, the stars or cosmos, the Van Allen belts, the artificial electron belt, and from nuclear reactor powerplants, radiation protection programs have been established.

The Project Mercury astronauts were protected from such radiation because their flights were not subjected to the more intense radiation of the Van Allen belts and because the earth's magnetic field protected them from solar flare radiation. However, radiation exposures of crews of future Project Apollo manned lunar explorations represent a major problem. For this reason this radiation must be analyzed with the utmost precision, its biological effects understood, and Apollo astronauts shielded against it.

Tiny battery-operated red lights have been added to the tips of the index and middle fingers of astronauts' gloves to help them see instrument panels and adapt to periodic darkness when in orbit. This innovation, devised by NASA bioscientists, proved to be very helpful during the first two U.S. manned orbital flights. (See fig. 8–1.)

Physiologists of NASA's bioinstrumentation staff have developed an improved blood-pressure cuff to monitor an astronaut's blood pressure when he is in flight. (See fig. 8–2.) Unlike the original cuff, which impaired mobility by constricting the fleshy belly of the muscle, the new cuff permits freer movement because it is contoured to avoid this part of the muscle. The cuff is worn under the pressure suit and inflated by the astronaut when he wishes. A microphone relays data to the medical monitor on the ground.

The pressure suit designed for Project Mercury has been under a continual process of evolution. Modifications to the basic suit have been dictated by spacecraft requirements, special tests, flight experience, and experience gained through mockups. (See fig. 8–3.)

Project Gemini pressure suits—the next generation to be worn during extended space flights—will have to be designed for 7 to 14 days of wearability. Among the changes required will be detachable arm and leg sections. A major redesign will be in the lower torso to facilitate human waste handling.

The Apollo suit—a still more sophisticated model for lunar exploration—will need a self-contained life-support pack if astronauts are to survive on the moon where temperatures range from 250° F. below to 250° F. above zero.

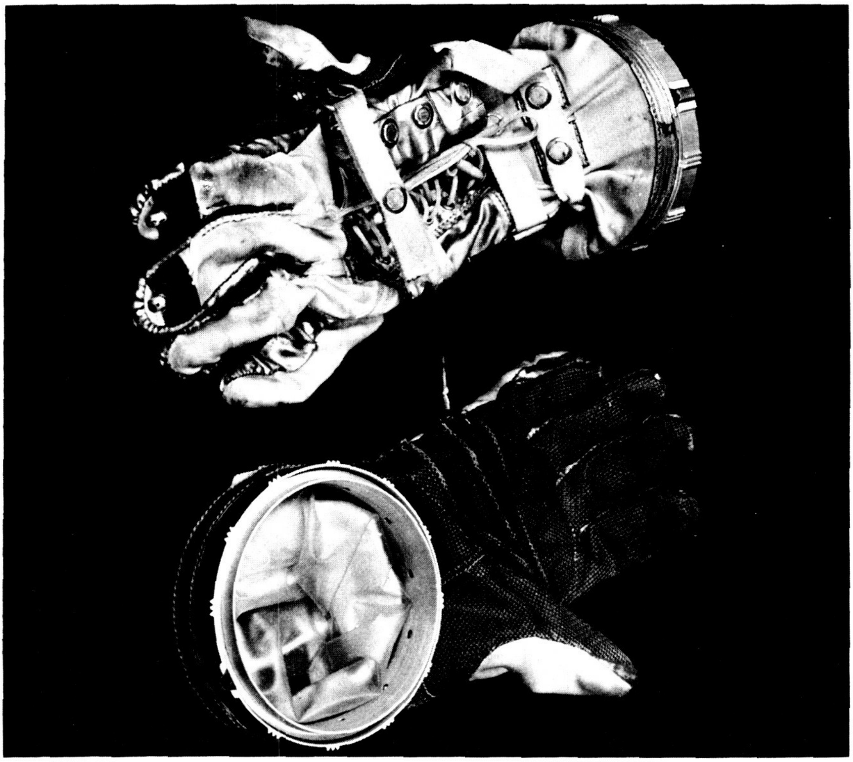

Figure 8–1. Gloves of Mercury pressure suit show finger-tip lighting.

BIOLOGY AND EXOBIOLOGY

NASA's expanding life science programs are placing greater emphasis on research in physical biology, environmental biology, and exobiology.

Physical biologists are investigating the physiological stresses of vibration, noise, weightlessness, radiation (see fig. 8–4), and acceleration that living organisms might encounter in space flight. In addition, they are studying the metabolic and nutritional requirements of living systems under simulated conditions of outer space and intensifying their efforts to design and produce more sophisticated instruments to measure the now unmeasurable in biology, physiology, and biochemistry.

Environmental biologists are studying the effects of zero g, magnetic forces, cosmic radiation, and the hard vacuum of space on various life forms either by placing specimens aboard space probes or satellites, or by simulating known environmental conditions of other planets in their laboratories. Further, these biologists are experi-

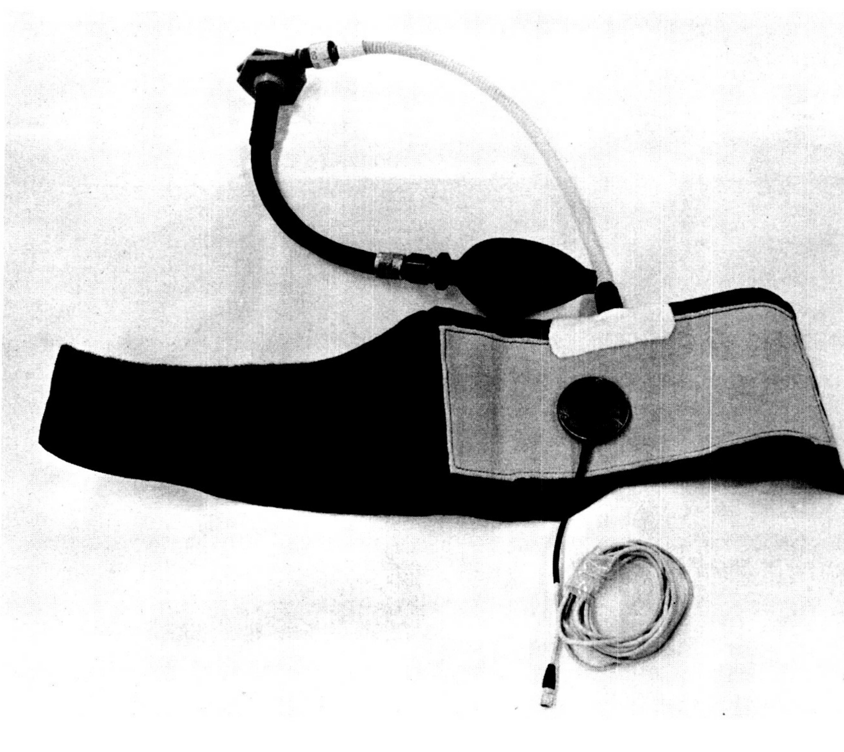

Figure 8–2. Contoured blood pressure cuff, squeeze bulb, and microphone.

Figure 8–3. Project Mercury pressure suit.

menting with organisms for use in space exploration—algae to supply astronauts with oxygen and food; hibernators to study the feasibility of induced sleep for future astronauts.

Exobiologists are delving into the evolution of life beyond our own planet. Their investigations include tracing the origin of life in the solar system; re-creating in the laboratory earth's primeval atmosphere; analyzing meteorites for traces of life; sampling earth's upper atmosphere for planet-to-planet "seeding" of living matter; studying planetary atmospheres with infrared spectroscopes; landing

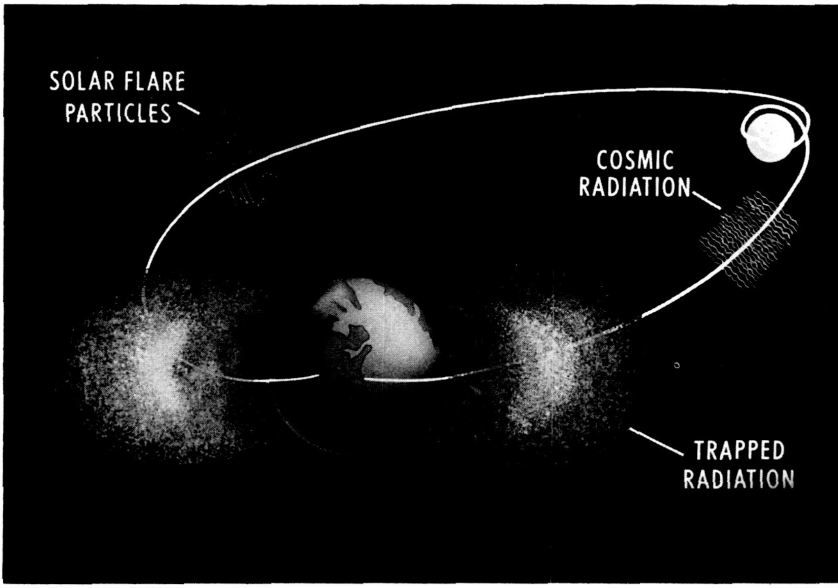

Figure 8–4. Astronauts face exposure to several types of radiation in lunar exploration.

instrumented spacecraft on Mars to identify any living organisms; and, finally, exploring the moon and the planets in search of extraterrestrial life.

Effects of Exposure to Manmade Atmospheres

Under a 3-year contract with NASA, Ohio State University will investigate the effects of prolonged exposure of small mammals such as mice, rats, guinea pigs, and rabbits to an artificial environment low in nitrogen and under controlled pressure, humidity, temperature, and gas composition.

Long-term exposure to low nitrogen or nitrogen-free atmosphere is known to affect the bone growth and development of these small mammals. The Ohio State scientists will attempt to determine if such effects could prove damaging to various fundamental biological and biochemical processes of men in space exploration.

Ground-Based Studies of Outer Space Stresses

Studying the effects of the space environment on life forms by sending them aloft on satellites or probes is costly and complex. NASA is, therefore, making maximum use of space-simulated conditions in a number of laboratory studies. (See fig. 8–5.)

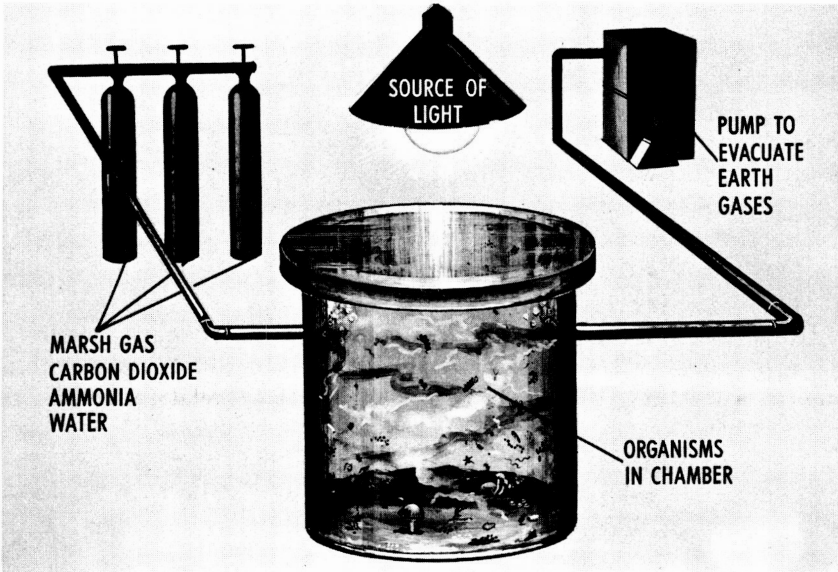

Figure 8–5. Environments of space and the planets studied in simulated atmospheres.

Research scientists at the Space Sciences Laboratory of the University of California are studying the effects on rats and the flour beetle *Tribolium* of radiation exposures of the inner Van Allen belt as simulated by the university's 184-inch synchrocyclotron. Damage to the beetles irradiated in this "atom smasher" has been found to be greater when high temperatures prevail. Future flight experiments will place beetle embryos and yeast cells aboard satellites to determine the radiation effects of the outer Van Allen belt.

Studies of weightlessness at Pennsylvania State University have determined that larger cells (i.e., those exceeding 10 microns) at zero gravity would be more greatly affected by weightlessness than bacterial systems. Bioscientists consider that developing cells such as cartilage are the best subjects for studying the weightless state of test forms in orbiting satellites.

Magnetic fields might be used in propulsion systems of future manned spacecraft or to shield astronauts from cosmic radiation. Accordingly, the U.S. Navy School of Aviation Medicine is investigating the effects of strong magnetic fields on man and animals. Man's reaction to zero magnetism is also under study.

According to research scientists at St. Louis University, hibernating organisms can better withstand higher radiation exposures since radiation effects are delayed until after recovery from hibernation.

Gravity may cause directional movement of plant hormones involved in growth processes. It is believed that by rotating a plant on its stem axis asymmetrical growth will result by preventing unidirectional gravity. Investigators at Dartmouth College and at the Atomic Energy Commission's Argonne National Laboratory are rotating growing specimens to determine what effects the prevention of this unidirectional gravity may have on plant development.

Life scientists at AEC's Oak Ridge National Laboratory are helping NASA produce biopacks to carry bacteria, mold spores, and mice in space satellites for radiation research projects.

Preparatory to flight tests, primates, and selected rodents, including Chinese hamsters, are being subjected to various levels of radiation and to high magnetic fields to determine their relative biological effects.

A miniature chamber to grow algae for gaging oxygen production has been designed and tested by the University of Minnesota. The chamber would be used in a space satellite to measure photosynthesis under weightlessness conditions.

A special microscope—inside an ultracentrifuge duplicating the increased gravity of Jupiter and Saturn—is being used by bioscientists of the University of Texas to study the effects of such an environment on various micro-organisms. The reactions of organisms to decreased and increased magnetic fields are also under investigation at the university.

Life scientists are investigating the survival and growth of bacteria, lichens, and mosses under a simulated Martian environment. (See also the space simulation studies described in ch. 9 of NASA's sixth semiannual report.) The bacteria *Clostridium botulinum* and *Bacillus subtilis* have survived 10 months in the Martian atmosphere duplicated; *B. subtilis* showed some growth. Preliminary studies of algae indicate that some lichens and mosses have also survived.

Further Studies of Life's Origin

NASA extended its studies of the origin of life by contracting with the University of Houston to investigate, under theoretical primeval conditions, various organic chemical compounds making up the nucleic acids. The nucleic acids are the organic chemical compounds that make up the hereditary material. If their composition can be altered in laboratory experiments, it may be possible to trace the origin of the characteristics of living things back to these primeval forms. Such information would bear directly on man's ability to explore and exist on other planets.

NASA also supported research at the University of Detroit on another essential step in the development of life—the evolution of chlorophyll in plants and hemoglobin in animals from the primeval atmosphere of the earth.

NASA-supported research is also conducting studies to determine whether or not life could have been "seeded" from planet to planet in the solar system. Plans were completed to launch plastic balloons in July and October carrying air samplers to capture micro-organisms floating freely 35,000 to 65,000 feet above the earth. These sampling surveys, to see whether microbes and spores can survive in the stratosphere, will test the "panspermia" or "seeding" theory.

Life Detection Devices

NASA is developing a variety of life detection systems to be carried aloft as part of the payload of instrumented planetary spacecraft such as Mariner and Voyager. In addition to the radioisotope biochemical probe, the "Wolf trap," and "J" band formation (see table 4, sixth semiannual report, p. 119), work progressed on several other systems. (Figs. 8–6 and 8–7.)

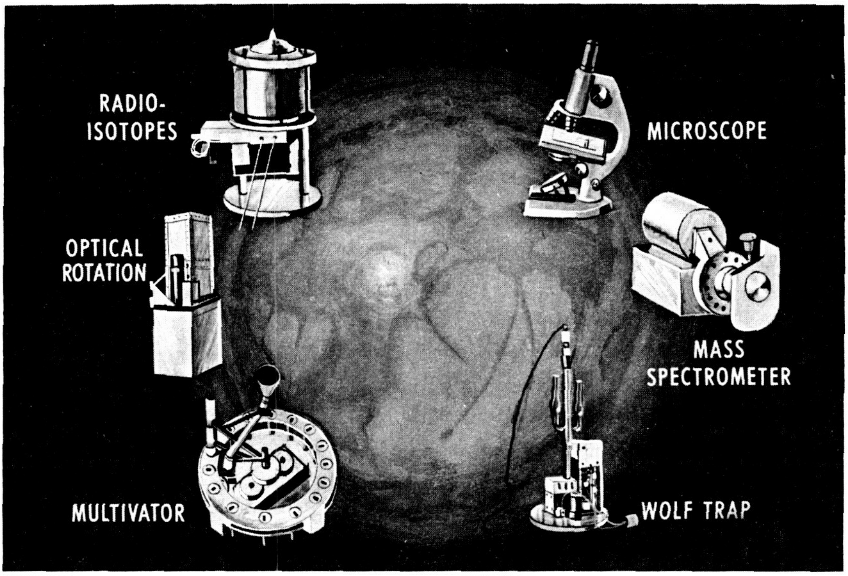

Figure 8–6. Devices used in searching for extraterrestrial life.

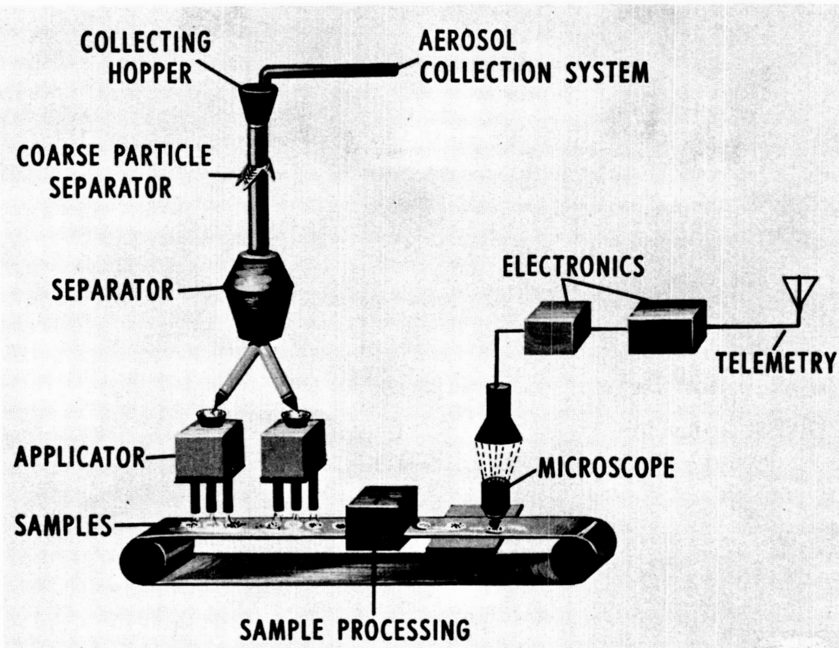

Figure 8–7. TV microscope to detect Martian organisms as small as 1/10,000 of an inch

Optical Rotation.—Design work continued on an instrument to use certain types of light such as ultraviolet to indicate the presence of living matter in the space environment.

Mass Spectrometer.—A research project at the Massachusetts Institute of Technology explored the possibility of identifying and studying life on Mars by using a mass spectrometer. The device works on the principle that the ions (electrically-charged atoms) making up life-related compounds have different masses that provide an interpretable spectrum on a photographic plate.

International Programs

NASA's Office of International Programs cooperates with the Department of State in carrying out the mandate of the National Aeronautics and Space Act of 1958 that U.S. space activities be conducted in cooperation with other nations and groups of nations for the benefit of all mankind.

As this reporting period closed, 57 countries had united with NASA in joint-flight, flight-support, or training programs—an increase of 7 nations since the last semiannual report to the Congress. These cooperative scientific ventures have brought to bear on the problems of the space age the talents of scientists from all over the world. Moreover, the information so generated is made available freely to the entire scientific community. The most noteworthy aspect of the program is that it is truly mutual—each participating nation supporting (without exchange of funds) its own portion of the joint undertaking.

Especially outstanding facets of this international program are the assistance of other countries in continuing support of the Mercury tracking network, which performed perfectly during the Nation's first manned orbital flight in February, the orbiting of the American-British ionosphere satellite Ariel, and the help of other nations in setting up the ground observation stations for the U.S. weather satellites.

Future experimental communications satellites will involve ground terminals to be built by Britain, France, Germany, Italy, and Brazil.

In geophysics and astronomy, the launching of the first international ionosphere satellite, the United States–United Kingdom's Ariel, was a cooperative effort of the two nations. It is described in chapter 3, Scientific Investigations in Space.

OPERATIONS SUPPORT

NASA began to explore the possibility of establishing a tracking and data-acquisition station in the Far East, including the Philippines and Japan, to support the Eccentric Orbiting Geophysical Observatory (EGO) and the Orbiting Astronomical Observatory (OAO). A deep space tracking facility in Europe for lunar and planetary exploration programs is likewise under consideration.

Canada has granted NASA permission to conduct a series of balloon flights from Labrador for scientific research. The flights will measure exposures of payloads to high-energy particles for 54 hours at an altitude of about 127,000 feet.

Bermuda has agreed to allow Arcas-Robin rockets to be launched from the islands in connection with Scout reentry tests.

Telespazio, an Italian agency for communications satellites, has signed a memorandum of understanding with NASA, (subject to confirmation by the Governments of Italy and the United States) to participate in Relay and Telstar experiments on a narrow band, receiving basis only.

The Japanese Ministry of Posts and Telecommunications is discussing with the Agency possible cooperation in communications satellite experiments; India and the Scandinavian Committee for Satellite Communication have also shown an interest in such experiments.

COOPERATIVE PROGRAMS

Australia

NASA and the Australian Commonwealth Scientific and Industrial Research Organization have agreed to conduct a cooperative sounding rocket investigation of very-low-frequency radio noise in areas above the ionosphere. Under the terms of the agreement American rockets carrying Australian radio instruments will be launched from Wallops Island late in 1962.

Canada

Four Canadian Black Brant sounding rockets were launched from Wallops Station in June by NASA for the Canadian Armaments Research and Development Establishment. Although primarily vehicle flight performance tests, the rockets carried instruments to study cosmic rays and magnetic fields.

The joint United States-Canadian Alouette satellite, designed to explore the structure of the ionosphere, is scheduled for launch by a NASA Thor-Agena B vehicle late in 1962.

France

A U.S. sounding rocket carrying a very-low-frequency radio-propagation experiment prepared by French scientists will be flown from Wallops Island in 1963, in accordance with an arrangement with France's Space Committee. Pending an evaluation of this initial flight, a decision will be made on whether to set up a joint satellite project for conducting similar measurements.

Italy

In June a three-phase United States-Italian cooperative satellite program was inaugurated. The scientific venture is expected to culminate in the launching, by a NASA Scout vehicle, of an Italian atmospheric density satellite into an equatorial orbit from a towable platform in the Indian Ocean. In the first two phases of the program, sounding rockets will be used to test the payload and a prototype satellite will be orbited from Wallops Island.

Japan

A joint United States-Japanese ionospheric electron temperature probe was launched on a Nike-Cajun sounding rocket from Wallops Island on April 26, marking the first cooperative flight in a program being undertaken by scientists of the two countries. Two other successful launches on May 19 concluded the series. The payloads were instrumented by Goddard Space Flight Center and the Japanese Radio Research Laboratories.

Pakistan

First launchings in the United States-Pakistan upper atmosphere sounding rocket program were successfully conducted from a site west of Karachi on June 7 and 11. Sodium vapor payloads were launched on Nike-Cajun sounding rockets by Pakistanis trained at Goddard Space Flight Center and at Wallops Station to operate the ground instruments and analyze the data. NASA supplied the sounding rockets, furnished the launchers, and provided technical assistance.

Sweden

Nike-Cajun sounding rockets to investigate high altitude bright nighttime clouds in the arctic area of Sweden will be launched in August under NASA and the Swedish Space Committee sponsorship. The Goddard Space Flight Center; Cambridge (Mass.) Research Laboratory (AFCRL), and the Stockholm Meteorological Institute will participate in payload instrumentation, ground support, and data analysis.

United Kingdom

The first international ionosphere satellite—the United States-United Kingdom's Ariel (S–51)—was placed in orbit on April 26. (See ch. 3 for details.)

Work continued on the second joint satellite in this series (the S–52) scheduled to be launched in 1963; preliminary discussions were held with the British Space Committee regarding experiments for possible inclusion in a third satellite of this project (S-53).

U.S.S.R.

Following an exchange of letters between President Kennedy and Premier Khrushchev concerning proposed joint ventures in the peaceful uses of outer space, Deputy Administrator Dryden and Academician Blagonravov met in New York in March and in Geneva in May and June to discuss specific areas of cooperation. The two agreed on proposals for cooperative efforts between the United States and Russia in meteorological satellites, geomagnetic mapping, using satellite instrumentation, and communications tests by means of satellites. If the proposals are approved by both Governments, detailed arrangements will probably be worked out later in 1962 by experts from the two countries.

Ionosphere Beacon Satellite

Over 50 scientists from 21 countries have expressed an interest in conducting ground-based experiments using signals from the Ionosphere Beacon Satellite (S-66). The S-66 is scheduled to be launched early in 1963 to study the composition and behavior of the electrified levels of the atmosphere.

Geodetic Satellite

The Agency has enlisted the participation of the world's earth scientists in Project ANNA, a plan to use a geodetic satellite to map the globe and study its gravitational field and internal composition. Project ANNA (for Army, Navy, NASA, and Air Force) was announced by the Agency at the Third International Space Science Symposium and Fifth Plenary Meeting of the Committee on Space Research (COSPAR) held in Washington, D.C., on April 27.

ANNA will be launched by the Department of Defense, which also supplied the spacecraft's instruments. NASA is arranging for international scientific observers to make observations from the ground and supply NASA with data collected.

PERSONNEL EXCHANGES

During the report period 1,486 foreign nationals visited NASA facilities—a 100-percent increase over previous periods. Included were officials of space programs in Argentina, Australia, Belgium, Brazil, Canada, Czechoslovakia, Federal Republic of Germany, France, India, Italy, Japan, the Netherlands, Norway, Pakistan, Poland, Republic of South Africa, Sweden, Switzerland, the United Kingdom, and the U.S.S.R.

Delegates to the Committee on Space Research toured NASA facilities, as did members of the United Nations Committee on the Peaceful Uses of Outer Space, delegates to the International Radio Consultative Committee, and delegates to the Commission for Synoptic Meteorology of the World Meteorological Organization.

NASA sent abroad 145 scientists to participate in international conferences and symposia during this period.

Education and Training Programs

Seven students from five countries are studying the space sciences at six American universities under NASA's international fellowship program. This fellowship program envisions 25 to 100 foreign students participating annually at 18 to 30 U.S. universities on a shared-cost basis.

The European Preparatory Commission for Space Research will give financial support to 15 fellowships under the Agency's international university program for the 1962–63 academic year.

Fourteen students from three countries are receiving training in space research at Goddard Space Flight Center and Wallops Station.

Columbia University's Summer Institute in Space Sciences, conducted under a NASA grant, has been expanded from a scholarship program for outstanding American undergraduates to include 15 to 20 foreign students.

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Management, Procurement, Support, and Services

Matching the tempo of the Nation's accelerating space programs during the first 6 months of 1962, NASA increased its educational, informational, and related services; planned more efficient management; added to its staff of specialists to carry out its expanding activities; and effected greater economies in its procurement methods.

EDUCATIONAL PROGRAMS AND SERVICES

Serving a mounting public demand for information about the Nation's civilian space projects and helping to meet the needs of education for the space age, NASA's educational programs provided nontechnical publications; motion pictures and exhibits for professional, scientific, and technical audiences and for the general public; speakers for meetings of professional, civic and other organized groups; and advisory services and program assistance on space science and exploration for educational entities at all levels in nearly every State.

Publications

Among the educational publications issued were: "Space, The New Frontier," a 48-page illustrated booklet describing peaceful exploration of space and furnishing a résumé of each NASA project; "Field Installations," brief descriptions of the role in the Nation's civilian space program of each NASA field installation; "NASA Facts" on the Ranger unmanned lunar exploration spacecraft and the orbiting solar observatory, the first two of a series of fact sheets adaptable to wall display or insertion in looseleaf notebooks and distributed primarily to science teachers; "Astronaut John H. Glenn Orbits the Earth for America" and "The Earth-Orbiting Flight of Astronaut M. Scott Carpenter," pictorial descriptions of America's first and second manned orbital flights; "Aeronautics and Space Bibliography—A Bibliography of Adult Aerospace Books and Materials"; and leaflets entitled "Man Must Take Environment Into Space" and "Administration and Management of Space Exploration," by James E. Webb, NASA Administrator, and "The National Significance of the Augmented Program of Space Exploration," by Dr. Hugh L. Dryden, NASA Deputy Administrator.

Figure 10–1. Some NASA educational publications.

Reprints were made of: "Man on the Moon," an illustrated article from the New York Times Sunday Magazine; and "The Moon, America's Most Difficult Endeavor," by Mr. Webb, and "Industry's Toughest Assignment," by Dr. Dryden, statements on the Nation's program to land an American on the moon, from Missiles and Rockets magazine.

(Limited quantities of these and other educational publications are available to the public without charge. See app. D for listings.)

"Spacecraft," the first of the Vistas of Science paperback books on space science and exploration, sponsored by NASA and the National Science Teachers Association, was produced in braille and voice-recorded for distribution to the blind through the Library of Congress. The NSTA also is publishing the book in several foreign languages.

The Vistas of Science series is designed to provide accurate, up-to-date scientific information in inexpensive format to students, teachers, and the general public. NASA is providing support and guidance for a five-volume series on space sciences and space programs. The release of "Spacecraft" in December 1961 inaugurated the series. The second volume, "Challenge of the Universe," was issued shortly after the end of this report period.

"Projects: Space," a paperback designed to provide teachers and high school students with better understanding of the Nation's space program and its career opportunities, was released in March. It was published by Science Services, Inc., under NASA contract. Initial distribution was to supervisors of approximately 28,000 science clubs in high schools throughout the United States and to secondary school principals.

Motion Pictures

NASA released two major films during the period. Each is in sound and color and runs 58 minutes. One film, "The Mastery of Space," tells the story of Project Mercury, America's program for placing a man in orbit and returning him safely to earth. Featured is the orbital flight of John H. Glenn, Jr. Also described are Projects Gemini and Apollo.

During the report period there were 370 telecasts of "The Mastery of Space;" 307 by commercial television stations and networks, and 63 by educational television.

The second film, "Friendship 7," depicts the orbital flight of John H. Glenn, Jr. This film was telecast 71 times during the report period. Of these, 60 were by commercial television stations and 11 via educational television. "Friendship 7" was released in full length initially through the National Broadcasting Co.'s network of 180 commercial television stations. For USIA use overseas, NASA has provided 500 prints of "Friendship 7" and 54 prints of "The Mastery of Space."

By June 30, 1962, NASA had stored and cataloged 3,513,166 feet of stock film showing scenes of spacecraft and launch-vehicle development, launching, and other space activities. During this period, NASA made available 288,854 feet of such film to fill requests from educational and documentary film producers.

NASA has also prepared a series of short silent technical films for use by lecturers before scientific, technical, and other special audiences.

(NASA films are available to the public without charge except for return mailing and insurance costs. See app. D.)

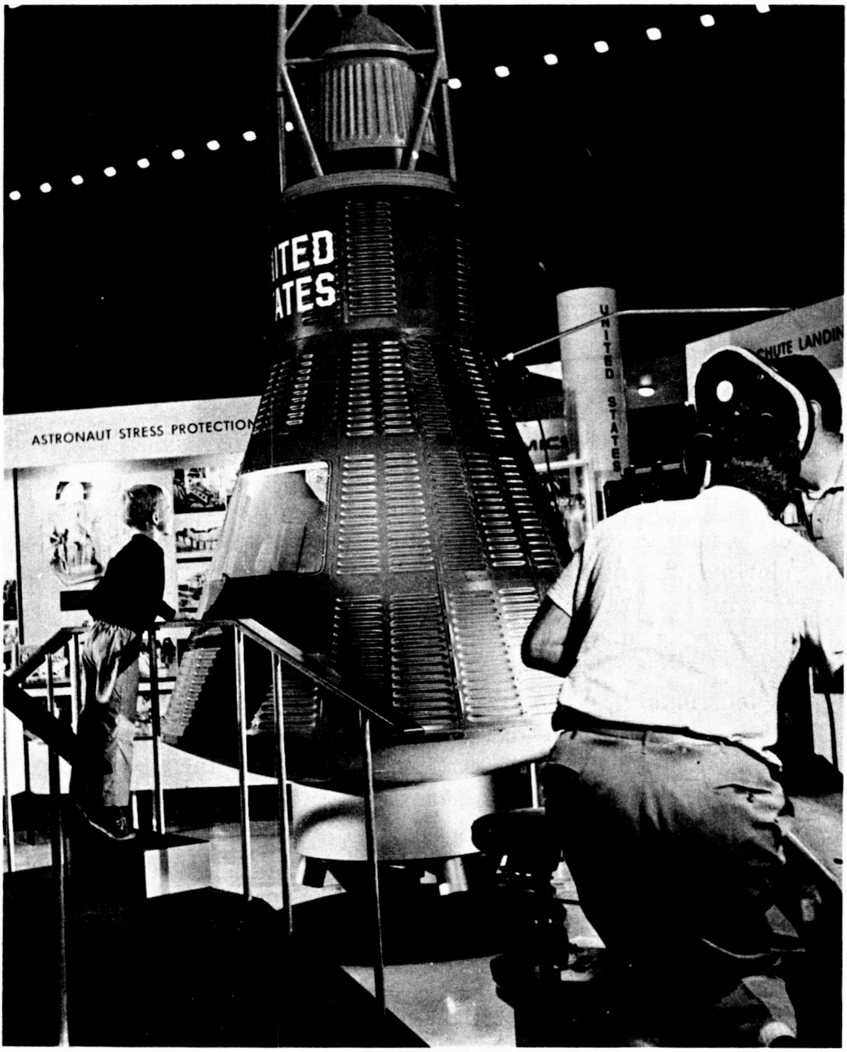

Figure 10–2. Filming NASA's The Mastery of Space.

Speakers for Institutes and Seminars

On request, NASA provides colleges and universities with assistance, cooperation, and collaboration in teacher-training activities requiring space science and NASA program information. NASA staff members participated in and provided lectures, demonstrations, exhibits, and publications at more than 75 institutes and seminars during the report period.

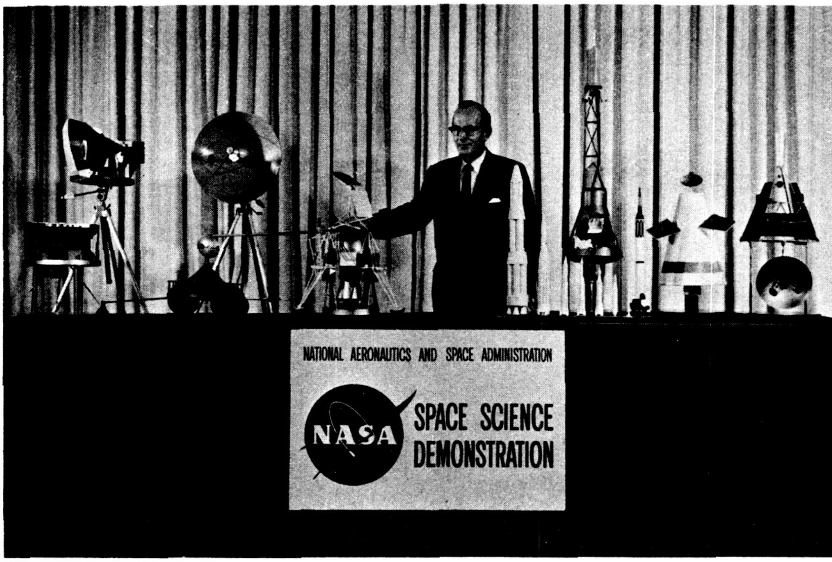

Figure 10–3. Spacemobile models help illustrate NASA projects.

The Agency and eight colleges and universities are collaborating in an experimental program leading to development of curriculums which can be usefully employed in aerospace instruction. In this project, teams of science and mathematics teachers and of supervisors and consultants are participating in workshops, institutes, and seminars on aeronautics and space to develop units to study for eventual employment in their classrooms. After evaluation and refinement, the best of them will be made generally available.

On request, NASA officials have spoken on the Nation's civilian space program before scores of civic and other organized groups and professional organizations.

Cooperation With State and National Educational Organizations

Arrangements have been made with 80 percent of the departments of education of the various States for specific utilization of NASA educational services. For example, employment of the NASA spacemobile (see fig. 10–4); assistance in planning subject matter presentations for teacher-training seminars, symposia, and institutes; and distribution of educational materials to teachers. NASA helped organize and conduct statewide aerospace education institutes in six States.

Working with the executive committee of the Southern States Work Conference, NASA staff members participated in planning a 3-year project on "Educational Challenges in Space Exploration." The conference is sponsored by the educational departments of 13 Southern States.

NASA participates in national programs conducted by such organizations as the National Education Association, National Science Teachers Association, National Council of Teachers of Mathematics, U.S. Office of Education, National Academy of Sciences, National Aviation Education Council, American Association of School Administrators, American Association of Elementary School Principals, and others.

An example of such cooperative activity is NASA participation in the National Science Fair—International Awards Program. Competing at the fair are regional student winners of secondary school science fairs. Their presentations include demonstrations and research studies carried out with nearly professional skill.

At the 13th National Science Fair—International, held in Seattle, Wash., May 2–5, NASA presented awards to two winners in each of three categories as follows:

Name	*Presentation*	*Category*
John Taboada, San Antonio, Tex.	Cosmic Rays Studied with a Counter - Controlled Cloud Chamber.	Space science.
Richard Lee Falwell, Bethesda, Md.	Spot Cycles of Jupiter and Saturn.	Do.
Susan Key Pilger, Arlington, Va.	Chemical Fuel Cell	Manned space flight.
Ross Gregory Sisk, Tallahassee, Fla.	Astro-Navigation	Do.
David A. Zavadil, Brookfield, Wis.	Plasma Acceleration	Rockets.
Bruce D. Pomeroy, Reading, Pa.	Effect of Expansion Ratio on the Thrust of Rocket Nozzles.	Do.

The winner and sponsoring teacher are each awarded a visit to the NASA laboratory most closely related to the winner's scientific investigation, and each winner receives a certificate signed by the NASA Administrator.

Spacemobiles

These are traveling space science demonstration units sufficiently versatile to interest audiences widely varying in age, educational, and vocational background. (See fig. 10–4.)

During the report period, NASA spacemobiles made presentations before relatively small groups aggregating about 250,000 persons. Among these were approximately 60,000 of the visitors to the Century 21 Exposition, Seattle, Wash., which opened April 21.

Spacemobile lecturers also made about 250 television appearances.

Figure 10–4. Spacemobile—NASA traveling space science demonstration unit.

Each spacemobile is operated by two qualified science teachers who employ models of spacecraft and launch vehicles and other graphic devices to describe and explain space science and technology and the U.S. civilian space program. A typical lecture runs about 50 minutes.

On June 30, NASA was operating 11 spacemobiles in the United States and had programed 2 for foreign use. One was in Pakistan, where a spacemobile lecturer was training several Pakistani science teachers preparatory to their touring and giving demonstrations in their country.

Elementary and secondary schools, colleges, and universities, and civic and professional organizations may obtain information on spacemobile presentations by contacting the Office of Educational Programs and Services, NASA Headquarters, Washington 25, D.C.

EXHIBITS PROGRAM

NASA exhibit showings totaled 245 during the report period as compared with 130 in the previous 6 months. By June 30, the rate of requests for exhibits was nearly double that of the previous year. Additional exhibits are being constructed to meet increasing demands.

Technical Exhibit at World's Fair

On April 21, a major NASA technical exhibit made its initial public appearance at the Century 21 Exposition in Seattle, Wash. By June 30, approximately 700,000 people had viewed the exhibit. On May 10, Vice President Lyndon B. Johnson dedicated NASA's exhibition "to international goodwill and cooperation in a worldwide venture into space."

The NASA presentation at the World's Fair covers about 20,000 square feet. It is organized into eight major areas: International Programs; Application Satellites (weather and communication); Scientific Satellites; Orbits; Tracking and Data Acquisition; Space Vehicle Technology; and Manned Space Flight. Illustrative panels and models of spacecraft, launch vehicles, and engines depict this country's program for the peaceful exploration and utilization of space.

Among the exhibit features is a full-scale mockup of the giant F-1 engine. Another attraction is a full-size replica of the lower end of the Saturn C-1 first stage. A recording of this booster's thundering takeoff is played in the vicinity of this model.

Fifty college students trained in science and mathematics and experts from NASA laboratories are available at the exhibit to answer questions relative to the Nation's civilian space program. Among the staff, 11 foreign languages are spoken.

World Tour of Friendship 7

Friendship 7, the spacecraft in which John H. Glenn, Jr. orbited the earth, has been viewed by 10 million people since the start of a world tour on April 20. Among countries on the itinerary are Spain, Nigeria, Mexico, Brazil, United Kingdom, Zanzibar, France, Japan, India, Burma, and Thailand. The spacecraft was to be shown at Century 21 prior to placement in the Smithsonian Institution in Washington, D.C.

Additional Education Information Activities

The U.S. Information Agency is presenting NASA exhibits in many locations overseas. The Agency is making worldwide showings of NASA displays on Pioneer V, which NASA launched into orbit around the sun on March 11, 1960, and on the TIROS meteorological satellite program. It has presented full-scale NASA Project Mercury exhibits in Rumania, Spain, Italy, Norway, Peru, El Salvador, and other countries.

HISTORICAL WORK

The historical staff continued to document significant developments in aeronautics and space and extended its coordination with other professional personnel and organizations to improve historical services. NASA filled numerous requests for historical references pertaining to U.S. space and aeronautic programs.

The following historical documents were completed: "Aeronautical and Astronautical Events of 1961" (reprinted by the Committee on Science and Astronautics of the House of Representatives, for sale by the Superintendent of Documents, Washington 25, D.C.); "Historical Origins of NASA" (a brief narrative—limited distribution); "History of Marshall Space Flight Center, July 1–December 31, 1961" (three volumes—limited distribution).

REPORTS TO CONGRESS

On January 31, NASA issued "Report to the Congress from the President of the United States—United States Aeronautics and Space Activities, 1961." NASA prepared the report with the cooperation of other Government agencies participating in the Nation's aeronautic and space programs.

"NASA's Fifth Semiannual Report to Congress—October 1, 1960, through June 30, 1961" was published in July. The sixth semiannual report, covering the period July 1 through December 31, 1961, was released in September.

SCIENTIFIC AND TECHNICAL INFORMATION

To meet the rapidly increasing demand for a wide range of informational products and services in the aerospace sciences, NASA, in January, established a central scientific and technical information processing facility. Under the Agency's close technical direction, the contractor-operated facility will employ advanced computer techniques to process information. The facility acquires and selects documentary materials to be added to the NASA collection; abstracts, indexes, and prepares announcements of the newly acquired materials; provides concurrent and continuing dissemination service and a supporting reference service; and compiles bibliographies in specialized subject areas.

This information-processing facility receives or acquires scientific and technical documents resulting from NASA-supported investigations, as well as documents derived from NASA interagency agreements with domestic and foreign organizations. Abstracts and indexes prepared by the facility are published biweekly in an announcement journal—"Technical Publications Announcements (TPA). The journal was greatly expanded to serve as a current announcement and information finding tool for scientists, engineers, technicians, etc. To increase its utility, indexes to all reports announced in TPA are cumulated on a quarterly, semiannual, and annual basis.

NASA reports are made available in both full-size copy and microform for rapid access by users. The 5- by 8-inch microform transparencies are distributed in advance of published announcements to ensure their availability throughout the NASA complex as soon as their existence is known to potential users.

Translation Program

The Agency's translation program is directed toward the fullest possible use of materials available from other agencies engaged in comprehensive translation programs. Supplementing these external sources, contracts were awarded in June to six firms for translations to support NASA's scientific and technical programs. Materials translated under extremely rigid contractual terms are furnished directly to the NASA requesting office at the same time that they are submitted for publication as NASA technical translations.

NASA participated with other Government agencies in the Public Law 480 Program (counterpart funds) during the reporting period. Thirteen titles of significant Russian works in aeronautics and space were submitted for translation under the program.

Funds were transferred to the National Science Foundation in May to provide for cover-to-cover translation of the first nine issues of Geomagnetizma i aeronomiya, a major Russian journal dealing with physical phenomena of the upper atmosphere.

Foreign Exchange Program

During the reporting period, NASA's expanding foreign exchange program almost doubled the number of foreign universities, institutes, Government agencies, and private organizations providing scientific and technical publications in return for NASA's materials. By the end of June more than 120 exchange agreements were in effect and another 50 were being negotiated.

Dissemination of Technical Information

In the first 6 months of 1962, the Office of Scientific and Technical Information answered nearly 21,000 requests for documents and furnished 80,000 publications to requesters. Most of these documents were NASA and NACA publications. Their dissemination supplemented the wide distribution these publications automatically receive at the time they are issued.

Technical Publications

During the reporting period, 9 NASA technical reports, 215 NASA technical notes, 79 NASA technical memorandums, and 6 special publications were released, as were 256 preprints or reprints of journal articles and conference proceedings describing NASA-sponsored research and development.

(See app. D for a selected listing of publications.)

PERSONNEL

In line with the Nation's expanding space program NASA increased its staff from 19,104 to 23,825 during the period covered by this report. Employment of scientists and engineers rose from 6,432 to 8,295, in spite of extreme difficulty in recruiting such specialists.

As of June 30, 1962, the Agency's employees were as follows:

Scientists and engineers in aerospace technology and related supervisory and management positions	7,992
Engineers, mathematicians, and other technical and professional personnel supporting the above group	303
Scientific and engineering assistants and technicians such as draftsmen, designers, computer specialists, and illustrators	3,391
Management positions in procurement, personnel, finance, technical information, education, and legal	1,838
Clerical and administrative positions	3,939
Skilled trades and craft employees and related skilled, semiskilled, and unskilled laborers	6,362

Included in the NASA staff are 75 foreign scientists and 139 military personnel on loan from the armed services.

(These figures do not include the 3,000 employees of the Jet Propulsion Laboratory, Pasadena, Calif., operated for NASA under contract with the California Institute of Technology.)

Comparative distributions of personnel on December 31, 1961, and June 30, 1962, were:

Organizational unit	*Dec. 31 1961*	*June 30 1962*
Ames Research Center	1,548	1,674
Flight Research Center	497	540
Goddard Space Flight Center	1,864	2,464
Langley Research Center	3,476	3,913
Lewis Research Center	3,048	3,815
Marshall Space Flight Center	6,054	7,207
Manned Spacecraft Center	1,163	1,807

Organizational unit	*Dec. 31 1961*	*June 30 1962*
Wallops Station	374	425
Western Operations Office	84	136
Headquarters	976	1,504
AEC–NASA Space Nuclear Propulsion Office	20	40
Total	[1] 19,104	[2] 23,825

[1] Includes 117 military personnel.
[2] This total includes military personnel, limited tenure employees, consultants, and others.

NASA has set up seminars in procurement and program management to develop its future executives. Over 280 have completed the course leading to a working understanding of policies, procedures, and practices inherent in the Agency's contracting program. About 75 have finished their studies in managing NASA's growing space activities.

Employees Honored

During this reporting period Robert R. Gilruth and Walter C. Williams, Director and Associate Director, respectively, Manned Spacecraft Center; M. Scott Carpenter, astronaut; and Joseph A. Walker, research pilot, received NASA's Distinguished Service Medal.

Awarded the Agency's Outstanding Leadership Medal were Hartley A. Soulé, Assistant Director of the Langley Research Center, and Paul F. Bikle, Director of the Flight Research Center, Edwards, Calif.

Other NASA employees received various honors as follows:

Neil A. Armstrong, senior pilot in the Dyna-Soar program, the Chanute Award for 1962; James V. Bernardo, Director of Educational Programs at Headquarters, the Frank G. Brewer Trophy; Merrill H. Mead, Ames Research Center, Spencer E. Smith and Robert G. Voss, Marshall Space Flight Center, Sloan Fellowships.

Robert Hutchinson, personnel officer, Goddard Space Flight Center, received the Civil Servant of the Year Award from the Federal Business Association of Maryland; Dr. Nancy G. Roman, Chief of Astronomy and Solar Physics at Headquarters, the Federal Woman's Award; Dr. Bernard Lubarsky, Assistant Chief, Nuclear Physics Division at Lewis Research Center, the Arthur S. Fleming Award; Wesley J. Hjornevik, Assistant Director for Administration at the Manned Spacecraft Center, the William A. Jump Memorial Award (honorable mention); and Dr. Abe Silverstein, Director, Lewis Research Center, the National Civil Service League Award.

Contributions Awards

Under the provisions of section 306 of the Space Act of 1958, NASA's Inventions and Contributions Board received 2,208 communications and evaluated 1,074 contributions. It made no awards.

Under the Incentive Awards Act of 1954, the Board rewarded 17 of the Agency's employees with monetary awards ranging from $50 to $1,000 for 12 patentable inventions. (See app. C for details.)

Waiver of Patent Rights

Under section 305 of the Space Act, the Inventions and Contributions Board denied two petitions for waiver of patent rights and gave one advisory opinion on a prospective petition for waiver. No waivers were granted.

Executive Personnel Changes

New Appointments.—Joseph F. Shea joined NASA as Deputy Director of the Office of Manned Space Flight, for Systems, on January 8. Mr. Shea came from the Space Technology Laboratories at Los Angeles, where from August 1961 he had served as Director of the BAMBI program.

Charles W. Fricke, on February 5, was appointed Project Manager for the Apollo Spacecraft development program—an office under the Director of the Manned Spacecraft Center at Houston, Tex. He had served as Chief of Research and later as Chief of Technical Staff for the General Dynamics/Convair Division.

Dr. Orr E. Reynolds became NASA's Director of Bioscience Programs in the Office of Space Sciences on February 11. Dr. Reynolds was director of space sciences in the Office of the Secretary of Defense.

James E. Sloan on February 19 was appointed Director of Integration and Checkout in the Office of Manned Space Flight. He was formerly manager of advanced engineering projects of RCA's Major Systems Division.

On April 2, James H. Turnock was appointed Assistant Director of Systems Engineering for Communications and Tracking, under Joseph Shea. Mr. Turnock came from International Business Machines Corp., where he had been employed since 1955 as chief of the company's program participation in NASA's Project Mercury.

Dr. Raymond L. Bisplinghoff was appointed Director, Office of Advanced Research and Technology, on May 4, succeeding Ira H. Abbott who resigned January 2. Dr. Bisplinghoff came from the Massachusetts Institute of Technology, where he had served as professor of aeronautical engineering from 1946 until he became deputy head of the department of aeronautics and astronautics in 1952.

Dr. Eugene B. Konecci was appointed Director of Biotechnology and Human Research in the Office of Advanced Research and Technology on May 29. Dr. Konecci was Chief of Life Sciences for the Missiles and Space Systems Division of Douglas Aircraft Co., Inc., Santa Monica, Calif.

Dr. Richard B. Morrison was appointed Director of Launch Vehicle Propulsion Programs in the Office of Space Sciences on June 1. Dr. Morrison came from the University of Michigan where he had served as chairman of the space sciences committee of the university's Institute of Science and Technologies.

On June 25, Walter L. Lingle, Jr. was appointed special assistant to the Administrator. He became Acting Assistant Administrator for Public Affairs, succeeding Dr. Hiden T. Cox, who resigned from that position, effective June 29. Mr. Lingle, a former vice president of the Procter & Gamble Co., had briefly served as Deputy Administrator of the Agency for International Development (AID).

On March 1, Morton J. Stoller was appointed Director of the Office of Applications. He had previously served as Acting Director and Assistant Director for Satellite and Sounding Rocket Programs.

Reassignments.—On March 5, James H. Chamberlin was appointed Project Manager for the Gemini project, an office reporting to the Director of the Manned Spacecraft Center, Houston, Tex. He had served as Chief, Engineering Division at the former Space Task Group and in the Manned Spacecraft Center.

James T. Koppenhaver was appointed Director of Reliability and Quality Assurance in the Office of Programs on May 6, succeeding Dr. Landis S. Gephart who resigned from the position on that date. Mr. Koppenhaver had joined the staff of this division in October 1960. He came from the Filtron Co., N.Y., where he served as project director for the "downrange interference program" and other projects.

Dr. John F. Clarke was appointed Associate Director and Chief Scientist in the Office of Space Sciences on May 20. Dr. Clarke had served as Director of the Geophysics and Astronomy Programs of the Office of Space Sciences. Dr. John E. Naugle succeeded him as Program Director.

On July 1, Dr. Kurt H. Debus was appointed Director of the new Launch Operations Center at Cape Canaveral, Fla. Since July 1, 1960, he had served as Director, Launch Operations Directorate, an entity of the Marshall Space Flight Center.

Resignations.—Dr. Alfred M. Mayo resigned on May 25, as Deputy Director of Aerospace Medicine in the Office of Manned Space Flight.

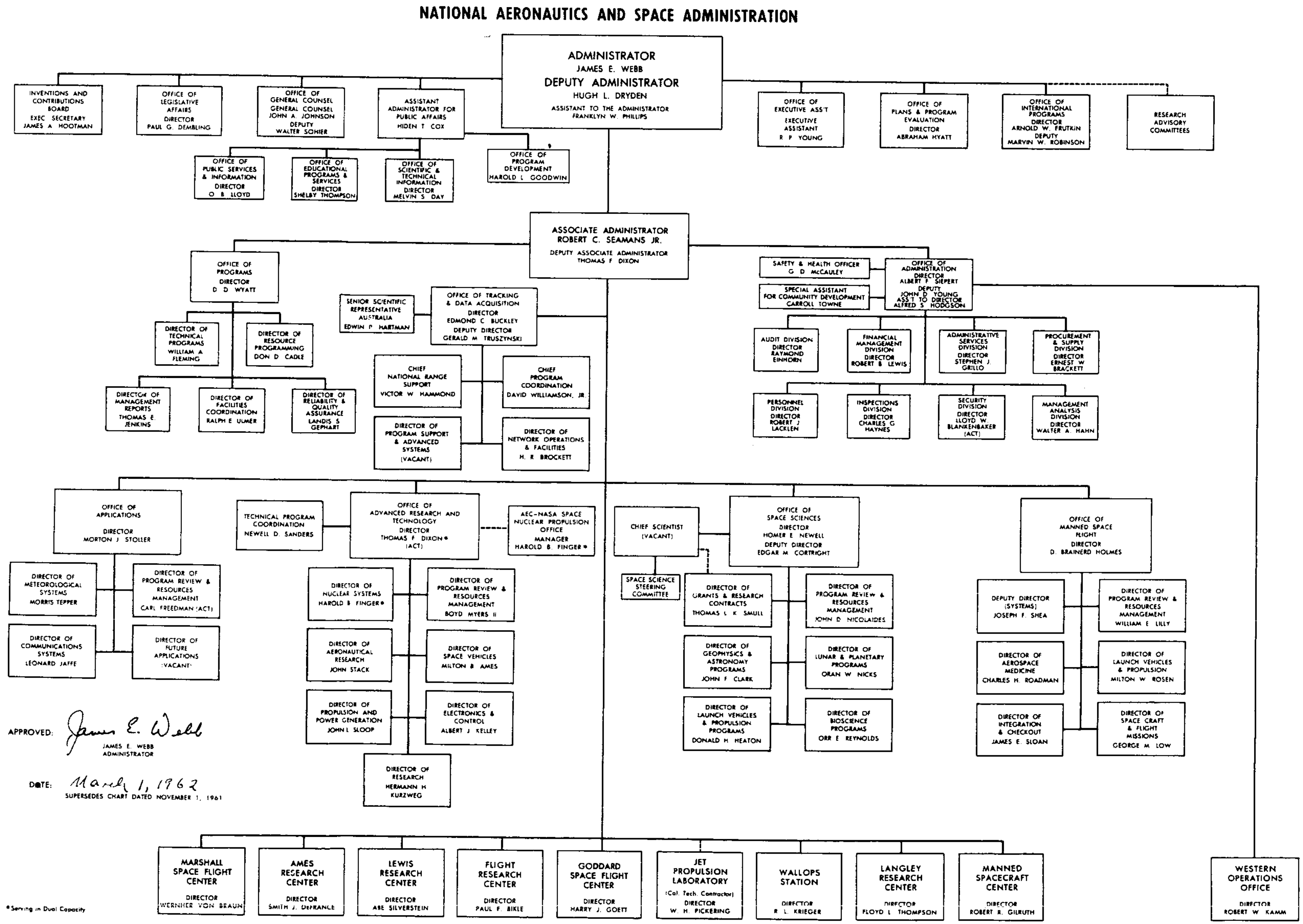

Figure 10–5. NASA organizational chart (March 1, 1962).

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During 1960–61 he served as Assistant Director for Bioengineering in the former Office of Life Science Programs.

John Stack resigned from the position of Director of Aeronautical Research in the Office of Advanced Research and Technology, effective May 31. Mr. Stack had been associated with the Langley Research Center since 1928. He served as Assistant Chief of Research from 1947 to 1952, and Assistant Director of the Center from 1952 until he became Director of Aeronautical Research on January 1, 1962.

ORGANIZATIONAL CHANGES

Assuring an immediate responsiveness to the needs of the manned lunar-landing program, NASA has established its launch facilities at the Atlantic and Pacific Missile Ranges as independent field installations.

The Cape Canaveral, Fla., facilities and the test-support office of the Pacific Missile Range (Point Mugu, Calif.) had been operated by a launch operations directorate reporting to the Marshall Space Flight Center at Huntsville, Ala. The Launch Operations Directorate at Cape Canaveral was designated the Launch Operations Center on March 7. It will serve all of the Agency's projects launched from the cape and report to the Office of Manned Space Flight at NASA Headquarters.

The Point Mugu test support office became the Pacific Launch Operations Office, reporting to the headquarters Office of Space Sciences.

As of March 1, 1962, the National Aeronautics and Space Administration was organized as shown by the accompanying chart.

OFFICE OF PROGRAMS

During the report period the staff of the Office of Resources Programing was expanded to improve procedures for preparing NASA's budgets. Accordingly, budget support functions were transferred from the Office of Administration to this reconstituted group.

PERT Cost Guide Published

Significant progress was also made in developing management systems to improve schedule and cost control of complex space programs. Concurrent development of such management systems by various Government agencies and their contractors has led to the derivation of a number of systems such as PERT (Program Evaluation and Review Technique).

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Since NASA and the Department of Defense utilize the same industrial base, it is extremely important that management and reporting system requirements imposed by both on their contractors be as uniform as possible without jeopardizing the usefulness of these systems as management tools for project managers.

To this end, NASA and the Department of Defense collaborated in formulating guidelines as a first step toward an eventual uniform NASA-Department of Defense PERT cost system. These guidelines—primarily aimed at developing a PERT cost system at the contractor or performing unit level—are in support of NASA's PERT and Companion Cost System now being implemented by NASA field centers on a number of the Agency's major projects and led to the joint publication of the NASA–DOD PERT Cost Guide in June.

NASA PERT and Companion Cost Handbook

Further, an up-to-date version of NASA's PERT and Companion Cost System Handbook was prepared and is being reviewed prior to publication.

The Agency also obtained Bureau of the Budget approval for the use of a Contractor Financial Management Report (NASA form 533) which, along with the handbook, serves as a basis for NASA's integrated time-cost management and reporting.

NASA Agencywide Coding Structure

NASA's Agencywide Fiscal Year 1963 Coding Structure (NPC 300–3) was released in July, just after the close of this report period. The extensive revision of the fiscal year 1962 code will serve as the basis for all NASA-wide management reporting.

Reliability and Quality Assurance

From January through June about 10,000 copies of the Agency's policy and implementation documents were published and distributed to NASA contractors and within NASA. These documents covered quality assurance concepts and procedures for inspection agencies, systems contractors, and components suppliers.

The contract for reliability abstracts and critical reviews was continued for another year to meet the growing demand for the monthly data sheets.

A research contract was initiated to investigate possible models that might predict configurations, performance, and the reliability of large complex space systems.

Reviews and Coordination of Future Space Mission Studies

NASA management established procedures to review and coordinate future space mission studies with its centers and headquarters Program offices. These procedures will be published as an official NASA manual of instruction.

PROCUREMENT MANAGEMENT

During the reporting period, NASA continued to explore ways of improving its procurement management. A concerted effort was made to achieve cost reductions in this area. Currently underway is a reevaluation of policies and practices governing the selection of various types of contracts directed toward providing maximum incentives for superior performance by NASA contractors through exploitation of the profit motive.

On an experimental basis the Agency has developed an incentive arrangement related to indirect expenses of a contractor which may prove an effective method of introducing cost controls on NASA contracts, particularly with companies where the volume of NASA contracts represents a major or substantial amount of a firm's business. Another method of achieving cost reduction, being used in several contracts, involves the use of a cost sharing arrangement wherein the cost participation by the contractor is evidenced by an agreement to accept an overhead rate lower than the anticipated actual overhead rate.

To guide the Agency's procurement officers in incentive contracting, a manual was drafted and is being reviewed. In addition, NASA's field installations have been directed to review their procurement programs to determine contractual situations in which performance or cost incentive features are appropriate.

Special Procurement Study Group

A study group was established to reevaluate the Agency's procurement policies to insure that NASA is not imposing requirements on industry and on itself that waste technical manpower, time, or money.

The group—composed of senior staff personnel from the legal, procurement, and technical program offices of NASA—is authorized to call upon outside organizations for advice and assistance.

Cost of Air Travel Reduced

Another item that received attention under this cost reduction program was the use of first-class air accommodations by NASA contractors. The Agency's contractors were encouraged to use less costly accommodations consistent with reasonable standards of comfort, convenience, and safety.

Contract Administration Office Established

For direct administration of contracts in the vital Apollo and Advanced Saturn II manned space flight programs, NASA established an office at the headquarters of its major contractor.

Publicizing Procurement Actions

During the reporting period NASA issued a regulation to publicize procurements offering competitive opportunities for prospective prime contractors and subcontractors. The regulation is designed to encourage greater competition, assist small business, aid firms in labor surplus areas, and broaden industrial participation in the Agency's procurement programs.

Quality Control in Administering Contracts

It is NASA policy that quality is a factor for consideration in each step of the procurement process. A regulation was issued that prescribes procedures for implementing NASA quality assurance policies in the performance of contracts for space systems, subsystems, components, and parts.

Review of Major Subcontracts

Insuring that procurement officers, as well as scientists and engineers at headquarters, be aware of the status of NASA's major subcontracts at all times, the Agency issued a regulation requiring procurement officers to submit information on subcontracts of an estimated $5 million or more to headquarters before placing these subcontracts. This procedure will also assure a headquarters review of the subcontract awards consistent with fundamental criteria governing sound procurement practices.

Small Business Program Management

Assuring small-business concerns a fair share of NASA's contracts and subcontracts, the Agency continued to work with the Small Business Administration in developing procedures to carry out congressional directives on small business set forth in the National Aeronautics and Space Act and the Small Business Act.

Small-business participation in the Nation's space programs and other procurement data are shown by the following statistical summaries.

Total Obligations and Procurement

During the 6 months ending June 30, 1962, NASA obligated approximately $921 million for procurement. Procurement actions by NASA Headquarters and its field procurement offices totaled about $71,000.

Awards to Business.—Approximately $715 million (77 percent) of the funds obligated represented purchases and contracts placed directly with business. About $27 million (3 percent) represented contracts and research grants awarded to nonprofit institutions or organizations; $26 million (3 percent) were obligated under a contract with the California Institute of Technology for the operation of the Jet Propulsion Laboratory; and $153 million (17 percent) were placed with or through other Government agencies.

Ninety percent of the dollar value of procurement requests NASA placed with other Government agencies resulted in contracts with industry. About 61 percent of the funds NASA obligated under the Jet Propulsion Laboratory contract was ultimately spent with business. Thus, about 94 percent of NASA's procurement dollars was contracted to private industry.

Competitive Procurements.—Approximately $34 million (5 percent) of the direct awards to business were placed through formal advertising for competitive bids. About $363 million (51 percent) were placed through competitive negotiations: proposals or quotations were solicited from more than one source, and the awards were based on price, design, or technical consideration. Thus, $397 million (56 percent) of the purchases and contracts placed directly with business were based on competitive procedures.

Small Business Participation.—NASA awarded $81 million in purchases and contracts directly to small business firms or about 11 percent of the total direct awards to business. Awards to small business resulted from about 41,000 actions, or 67 percent of the total number placed with business firms.

Approximately $14 million, representing 744 actions, of the awards to small business resulted from small-business set-asides.

Other Government Agencies Aid Procurement.—About $153 million (17 percent) of NASA's total procurement was placed with or through other Government agencies, primarily the Department of Defense. It is NASA policy to avoid duplication of effort and to use its own and DOD resources most effectively and economically. Thus, NASA purchases items through DOD which the military departments, because of their own programs, can buy from industry most economically. Some of the larger procurements were:

1. Air Force Systems Command, Washington, D.C. Design, develop, and fabricate Centaur upper stage vehicles, launch-vehicle technology, and vehicle procurement programs. Awarded—$28 million; cumulative awards—$62 million.
2. Army Engineers, Jacksonville, Fla. Land acquisition—north and west of present boundaries of Cape Canaveral, general administrative support program. Awarded—$11 million; cumulative awards—$30 million.
3. Air Force Systems Command, Inglewood, Calif. Titan II launch vehicles and equipment, Project Gemini, vehicle procurement program. Awarded—$25 million (new contract).
4. Air Force Systems Command, Washington, D.C. Atlas booster hardware and services to support NASA Agena B program, vehicle procurement program. Awarded—$13 million; cumulative awards—$29 million.
5. Army Engineers, Jacksonville, Fla. Design and construction of Complex 36B Atlantic Missile Range, Centaur program. Awarded—$10 million (new contract).
6. Army Engineers, Los Angeles, Calif. Control Center and support facilities for F–1 engine concept testing, liquid propulsion program. Awarded—$8 million; cumulative awards—$9 million.

Major Contract Awards.—Among the major research and development aggregate contract awards by NASA during the period were the following:

1. North American Aviation, Inc., Canoga Park, Calif. Study, research and development testing for a spacecraft which will carry three men to the moon and return to earth, Apollo program. Awarded—$60 million (new letter contract).
2. Douglas Aircraft Co., Inc., Santa Monica, Calif. Develop and fabricate Saturn S–IV vehicles and ground support equipment, Saturn program. Awarded—$33 million; cumulative awards—$74 million; total estimated cost—$83 million.
3. United Aircraft Corp., West Palm Beach, Fla. Design, development, production, and testing of LR115 A3 engine, Centaur and Saturn program. Awarded—$31 million; cumulative awards—$53 million; total estimated cost—$64 million.
4. Aerojet-General Corp., Azusa, Calif. Phase I—NERVA, nuclear-powered rocket engine, nuclear system program. Awarded—$29 million; cumulative awards—$35 million.
5. General Dynamics Corp., San Diego, Calif. Design and develop high-impulse upper stage vehicle, Saturn, Centaur, and communications satellites programs. Awarded—$23 million;

cumulative awards—$105 million; total estimated cost—$137 million.

6. North American Aviation, Inc., Canoga Park, Calif. Develop J–2 200,000-pound-thrust engine, liquid propulsion program. Awarded—$21 million; cumulative awards—$46 million; total estimated cost—$69 million.
7. McDonnell Aircraft Corp., St. Louis, Mo. Capsule, space parts, ground support equipment, training aids, technical data, and other related procurement for Mercury program. Awarded—$21 million; cumulative awards—$139 million.
8. North American Aviation, Inc., Canoga Park, Calif. Design and develop F–1, 1,500-pound-thrust engine, liquid propulsion program. Awarded—$20 million; cumulative awards—$117 million; total estimated cost—$125 million.
9. The Boeing Co., Seattle, Wash. Stage SIC preparatory effort, Saturn program. Awarded—$15 million (new contract).
10. Chrysler Corp., Detroit, Mich. Stage SI preparatory work, Saturn program. Awarded—$15 million (new contract).

Major Contractors.—Twenty-five of NASA's largest contractors are listed in appendix E of this report. (See p. 152.)

Grants and Research Contracts.—During the report period, NASA's Office of Research and Grants received 946 unsolicited proposals for research; 189 projects totaling $19 million were sponsored; 94 university projects amounted to $10.2 million, 54 percent of the total; 31 projects of nonprofit scientific research institutions amounted to $4 million, and 24 projects of governmental laboratories and agencies amounted to $2.3 million.

Recipients and amounts awarded are listed by State in appendix F.

FINANCIAL MANAGEMENT

Fiscal year 1962 witnessed a considerable increase in NASA's reimbursable services and procurement for other Government agencies and private enterprise. Total amounts were approximately $100 million and included such items as the Nimbus Operational System for the Weather Bureau ($52,390,000), procurement of Scout vehicles for the Navy and the Air Force ($18,350,000), and the Telstar project for the American Telephone & Telegraph Co. ($11 million).

The following tables show the financial operations of the Agency during the fiscal year 1962, and the planned program level for fiscal year 1963.

Fiscal Year 1963 Program

Table 1 shows the planned level of effort in the Research, Development, and Operation Appropriation by program area. This appropriation is the successor to the current Research and Development Appropriation, and includes the requirements currently funded under the Salaries and Expenses Appropriation.

TABLE 1—*NASA budget estimates fiscal year 1963*[1]

[In thousands]

Appropriation		*1963 estimates*
Research, development, and operation:		
Mercury	$13,259	
Advanced manned space flight	863,628	
Saturn C–1	249,237	
Advanced Saturn	335,172	
Nova	163,574	
Meteorological satellites	51,185	
Communications satellites	85,377	
Sounding rockets	19,157	
Scientific satellites	175,165	
Lunar and planetary exploration	273,560	
Scout	8,947	
Delta	268	
Centaur	66,664	
Spacecraft technology	54,084	
Launch-vehicle technology	31,690	
Launch operations development	21,486	
Electric propulsion	30,647	
Liquid propulsion	163,102	
Solid propulsion	7,944	
Space power technology	20,172	
Nuclear systems technology	122,962	
Aircraft and missile technology	52,588	
Tracking and data acquisition	158,410	
Total, research, development, and operation		$2,968,278
Construction of facilities		818,998
Total		3,787,276

[1] Submitted by the President to the Congress in January.

(The Salaries and Expenses title will be discontinued in fiscal year 1963.) The table also shows the planned level of effort in 1963 in the Construction of Facilities Appropriation.

Financial Report, June 30, 1962

Table 2 sets forth the total amount of funds obligated and expended during the fiscal year 1962, together with actions pending on June 30. A summary by appropriation gives current availability, obligations, and commitments against this availability, and uncommitted balances as of June 30.

TABLE 2.—*Status of fiscal year 1962 appropriation as of June 30, 1962*

[In thousands]

Appropriations	*Total obligations*	*Total expenditures*
Salaries and expenses	$216, 626	$196, 014
Research and development:		
Support of NASA plant	105, 770	84, 535
Research grants and contracts	11, 012	7, 318
Life sciences	13, 509	4, 951
Industry applications	5	0
Sounding rockets	10, 204	8, 812
Scientific satellites	60, 686	65, 647
Lunar and planetary exploration	116, 126	101, 595
Meteorological satellites	27, 147	23, 234
Communications satellites	23, 573	18, 617
Spacecraft technology	10, 890	8, 159
Space power technology	4, 833	3, 713
Mercury	26, 990	40, 040
Apollo	125, 141	38, 225
Launch vehicle technology	7, 759	3, 278
Launch operations development	3, 431	771
Solid propulsion	1, 210	724
Liquid propulsion	102, 936	78, 493
Electric propulsion	8, 887	5, 363
Nuclear systems	39, 465	21, 718
Scout	4, 390	4, 712
Delta	4, 147	5, 648
Centaur	72, 341	78, 394
Saturn	268, 164	195, 287
Nova	0	0
Vega	7, 715	8, 044
Vehicle procurement	138, 596	67, 212
Tracking and data acquisition	66, 414	51, 749
Reimbursable—other agencies	43, 037	21, 051
Total, research and development	1, 304, 378	947, 290
Construction of facilities	219, 626	114, 282

Appropriation summary	*Current availability*	*Total obligations*	*Unobligated balance*
Salaries and expenses	$217, 182	$216, 626	$556
Research and development	1, 443, 117	1, 304, 378	138, 739
Construction of facilities	414, 969	219, 626	195, 343
Total	2, 075, 268	1, 740, 630	334, 638

Appendix A

MEMBERSHIPS OF CONGRESSIONAL COMMITTEES ON AERONAUTICS AND SPACE

(*January 1–June 30, 1962*)

Senate Committee on Aeronautical and Space Sciences

ROBERT S. KERR, Oklahoma, *Chairman*
RICHARD B. RUSSELL, Georgia
WARREN G. MAGNUSON, Washington
CLINTON P. ANDERSON, New Mexico
STUART SYMINGTON, Missouri
JOHN STENNIS, Mississippi
STEPHEN M. YOUNG, Ohio
THOMAS J. DODD, Connecticut
HOWARD W. CANNON, Nevada
SPESSARD L. HOLLAND, Florida
ALEXANDER WILEY, Wisconsin
MARGARET CHASE SMITH, Maine
CLIFFORD P. CASE, New Jersey
BOURKE B. HICKENLOOPER, Iowa
HOMER E. CAPEHART, Indiana

House Committee on Science and Astronautics

GEORGE P. MILLER, California, *Chairman*
OLIN E. TEAGUE, Texas
VICTOR L. ANFUSO, New York
JOSEPH E. KARTH, Minnesota
KEN HECHLER, West Virginia
EMILIO Q. DADDARIO, Connecticut
WALTER H. MOELLER, Ohio
DAVID S. KING, Utah
J. EDWARD ROUSH, Indiana
THOMAS G. MORRIS, New Mexico
BOB CASEY, Texas
WILLIAM J. RANDALL, Missouri
JOHN W. DAVIS, Georgia
WILLIAM F. RYAN, New York
JAMES C. CORMAN, California
THOMAS N. DOWNING, Virginia
JOE D. WAGGONNER, Jr., Louisiana
CORINNE B. RILEY, South Carolina
JOSEPH W. MARTIN, Jr., Massachusetts
JAMES G. FULTON, Pennsylvania
J. EDGAR CHENOWETH, Colorado
WILLIAM K. VAN PELT, Wisconsin
PERKINS BASS, New Hampshire
R. WALTER RIEHLMAN, New York
JESSICA McC. WEIS, New York
CHARLES A. MOSHER, Ohio
RICHARD L. ROUDEBUSH, Indiana
ALPHONZO E. BELL, California
THOMAS M. PELLY, Washington

Appendix B

Membership of the National Aeronautics and Space Council

(January 1–June 30, 1962)

LYNDON B. JOHNSON, *Chairman*
Vice President of the United States

DEAN RUSK
Secretary of State

ROBERT S. MCNAMARA
Secretary of Defense

JAMES E. WEBB, *Administrator*
National Aeronautics and Space Administration

GLENN T. SEABORG, Chairman
Atomic Energy Commission

Executive Secretary
EDWARD C. WELSH

Appendix C

Patentable Inventions of NASA Employees Recognized by the Agency's Inventions and Contributions Board

(January 1–June 30, 1962)

Invention	*Inventor(s)*	*Duty station*
Multichannel variable pulse width oscillator.	R. L. Mossino G. G. Robinson	Ames Research Center.
Centrifuge mounted motion simulator.	Estin N. Baker Jess S. W. Davidsen	Ames Research Center.
Digital aspect sensor	James S. Albus	Goddard Space Flight Center.
Runway light unit	S. A. Batterson	Langley Research Center.
Horizon scanning active attitude orientation of stabilized space vehicles.	H. Douglas Garner H. J. E. Reid, Jr.	Langley Research Center.
Meteorite detection apparatus.	Wm. H. Kinard	Langley Research Center.
Printed armature	Wilhelm Angele	Marshall Space Flight Center.
Space vehicle packaging technique.	Wade E. Lanford	Langley Research Center.
Electrical connector	Wilhelm Angele Hans G. Martineck	Marshall Space Flight Center.
Air bearing	Billy C. Hughes	Marshall Space Flight Center.
Intermediate accuracy angular measurement system.	John R. Raskin R. J. Schwinghamer	Marshall Space Flight Center.
Plug and connector for miniaturized circuits.	Hans G. Martineck	Marshall Space Flight Center.

Appendix D

PUBLICATIONS AND MOTION PICTURES

GENERAL PUBLICATIONS

Space, the New Frontier.—A 48-page brochure, with photographs and diagrams, introducing the reader to space exploration and the programs of the National Aeronautics and Space Administration.

This Is NASA.—An illustrated folder, outlining the organization and functions of the National Aeronautics and Space Administration.

Selling to NASA.—April 1962 revised edition of a guide for firms seeking business in the aeronautics and space programs of NASA. (Available from NASA, Code BR, Washington 25, D.C., or any of the Agency's field installations.)

NOTE.—Single copies of publications are available upon request from Educational Publications, AFEE, National Aeronautics and Space Administration, Washington 25, D.C.

NASA Facts [1]

A series of 21- by 32-inch sheets describing selected NASA projects and programs, with photographs and diagrams. Sheets are designed for bulletin board display or for insertion in looseleaf notebooks. Those issued to date are:

NASA's Ranger Program.—The lunar exploration mission of Ranger.

Orbiting Solar Observatory.—Investigation of solar radiation.

Others are in preparation.

Space Exploration Leaflets

Each illustrated leaflet contains a statement by a NASA authority on an aspect of the NASA program. Leaflets issued to date are:

The National Significance of the Augmented Program of Space Exploration, by Dr. Hugh L. Dryden.—A statement of current status by NASA's Deputy Administrator and Chief Scientist.

Administration and Management of Space Exploration, by James E. Webb.—The organization of NASA, and new concepts which have been developed in programing and in personnel administration.

Others are in preparation.

Booklets and Folders

Astronaut John H. Glenn Orbits the Earth for America.—An illustrated booklet describing Colonel Glenn's three-orbit flight.

The Earth-Orbiting Flight of Astronaut M. Scott Carpenter.—Three dawns and three dusks in 4 hours and 53 minutes.

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[1] Sold by the Superintendent of Documents, Washington 25, D.C., who will furnish prices on request.

Echo I.—A folder describing the first of the passive communications satellites.

Exploring Space, Project Mercury.—A booklet describing the mission of the man-carrying Mercury spacecraft.

Exploring Space.—Projects Mercury, Gemini, and Apollo.—A booklet about manned space exploration.

Pioneer V.—A folder describing the space investigation role of Pioneer V.

TIROS.—A folder describing the role of the Television Infra Red Observation Satellite in weather forecasting.

Bibliographies [2]

Aeronautics and Space Bibliography of Adult Aerospace Books and Materials.

Aeronautics and Space Bibliography for Secondary Grades.

Aeronautics and Space Bibliography for Elementary Grades.

Reprints

Man on the Moon.—A short picture story of lunar exploration.

Why Spend $20 Billion To Go to the Moon, by James E. Webb.

The Moon: America's Most Difficult Endeavor, by James E. Webb, and *Industry's Toughest Assignment,* by Dr. Hugh L. Dryden.

Vistas of Science

A joint project of the National Aeronautics and Space Administration. The NSTA coordinates development of the manuscripts and establishes the educational acceptability of the books. NASA provides scientific and technical guidance and evaluation.

Spacecraft.[3]—Discusses various types of spacecraft and their functions, outlines the national program for peaceful utilization of space, and contains student projects relating to space flight.

The Challenge of the Universe.—On astronomy, by J. Allen Hynek and Norman Anderson.

These two will be followed by three more space science books in the Vistas of Science program:

The Thrust Into Space.—On propulsion by Everett Welmers.

Space Biology, by Samuel Moffatt and Joshua Lederberg.

Space Science Serves Man.—On the benefits of space exploration by Hugh Odishaw and Charles Helvey.

TECHNICAL PUBLICATIONS

Short Glossary of Space Terms.[4]—Brief definitions of 500 space terms from the *Dictionary of Space Terms* being prepared by NASA.

International Meteorological Satellite Workshop.[4]—Proceedings of the November 13–22, 1961, NASA—U.S. Weather Bureau sponsored workshop on the results of the Nation's meteorological satellite program.

[2] Sold by the Superintendent of Documents, Washington 25, D.C., who will furnish prices on request.

[3] The Vistas of Science (space series) books are published by and may be ordered from Scholastic Book Services, 33 West 42d Street, New York 36, N.Y., at 50 cents each.

[4] Sold by the Superintendent of Documents, Washington 25, D.C., who will furnish prices on request.

MOTION PICTURES

The following selected 16-mm. motion pictures are available to the public. There is no charge for film rental, but the requestor must pay return transportation and insurance costs.

General Interest Films

The Mastery of Space.—1962—58 minutes, sound, color. Traces the development of Project Mercury and briefly discusses Gemini, Apollo, and the Saturn booster. HQ–9.

This film should be ordered from: Associated Films, Inc., 347 Madison Avenue, New York 17, N.Y.

Friendship 7—1962—58 minutes, sound, color. Depicts the three-orbit flight of Astronaut John H. Glenn. Shows several international tracking stations.

This film should be ordered from: United World Films, Inc., 1445 Park Avenue, New York 29, N.Y.

Beating the Heat.[5]—1958—19 minutes, sound, color. Depicts some NASA facilities for studying aerodynamic heating and deceleration. HQ–1 (L–215).

Celestial Mechanics and the Lunar Probe.—1958—12 minutes, sound color, (animated film). Describes mechanics of guiding lunar probes. HQa–26.

NASA Roundtable—Scientists Discuss the Moon.—1960—18 minutes, sound, black and white; HQ–16.

Time and Space.—1959—27 minutes, sound, color. Describes the construction and launching of Juno II, Pioneer IV space probe. HQa–27.

United States Space Explorations.—1958—19 minutes, sound, color. U.S. space efforts from Explorer I to Pioneer III. HQ–8.

TIROS, Experimental Weather Satellite.—1960—13½ minutes, sound, color. HQa–25.

TIROS II.—1960—6 minutes, sound, color; advances in meteorological satellites since TIROS I. HQa–31.

Project Mercury, Congressional Report.—1960—33 minutes, sound color.

Project Mercury Report No. 2.—1960—30½ minutes, sound, color; photographic report; shows the progress of Project Mercury to the summer of 1960.

X–15—Documentary.—1960—27 minutes, sound, color. (Produced by North American Aviation, Inc., under contract for the joint Air Force/Navy/NASA project.) HQa–28.

Project Echo.—1960—27 minutes, sound, color. Tells the story of Thor-Delta I and Thor-Delta II. HQ–24.

Echo in Space.—1961—14 minutes, sound, color. (A short version of Project Echo, HQ–24.) HQ–37.

Saturn—Giant Thrust Into Space.—1961—10 minutes, sound, color. HQ–36.

Unmanned Spacecraft.—1961—14½ minutes, sound color. Dr. Hugh L. Dryden discusses space program aims; Dr. Homer E. Newell discusses current and future spacecraft. Launches of 1959 and 1960 are shown. HQ–38.

Flight of Freedom 7.—1961—10 minutes, sound, color. Newsreel of Astronaut Shepard's flight. HQ–47.

Freedom 7.—1961—28½ minutes, sound, color. This film deals with Astronaut Shepard's training, launch, recovery, and reception aboard the carrier, Lake Champlain. HQ–51.

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[5] Except for *The Mastery of Space* and *Friendship 7*, request films from: National Aeronautics and Space Administration, Code AFEE–3, Washington 25, D.C.

Astronaut Shepard Reports on Space.—1961—20 minutes, sound, color. Shows Astronaut Shepard receiving the NASA Distinguished Service Medal from the President May 8, 1961, and Shepard's press conference later.

Father of the Space Age.—1961—18 minutes, sound, black and white. Traces the development of Dr. Goddard's "moon rocket" research.

Technical Films

These technical motion pictures are intended for students, teachers of science and engineering, and scientists and engineers.

Aerodynamic Heating and Deceleration During Entry Into Planetary Atmospheres.—1958—29 minutes, sound, black and white. HQ–5.

Chemistry of Meteor Vaporization.—1960—29 minutes, sound, color. HQ–6.

High-Temperature Materials.—1958—27 minutes, sound, color. Tests of various materials to determine their suitability for high temperature applications. HQ–4.

Performance of Long-Range Hypervelocity Vehicles.—1958—30 minutes, sound, black and white. HQ–2.

How Did Life Begin?—1961—20 minutes, sound, color. Dr. Sidney Fox, Florida State University, discusses the evolutionary relationships of various protein molecules. HQ–32.

The Chemistry of Life.—1961—19 minutes, sound, color. Dr. Melvin Calvin, University of California, describes the chemical building blocks of life. HQ–33.

Life on Other Planets.—1961—21 minutes, sound, color. Dr. Joshua Lederberg, Stanford University, discusses the possibility of life existing on other planets. HQ–34.

Decontamination of Space Vehicles.—1961—18 minutes, sound, color. Dr. Charles Phillips and Mr. Robert K. Hoffman, Fort Detrick, Md., discuss the need for the decontamination of space vehicles. HQ–35.

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Appendix E

TWENTY-FIVE LARGEST CONTRACTORS

North American Aviation, Inc.
*Canoga Park, Calif.

Douglas Aircraft Co., Inc.
*Santa Monica, Calif.

McDonnell Aircraft Corp.
St. Louis, Mo.

Aerojet-General Corp.
*Azusa, Calif.

United Aircraft Corp.
*East Hartford, Conn.

Chrysler Corp.
Detroit, Mich.

General Dynamics Corp.
*San Diego, Calif.

Ling-Temco-Vought, Inc.
Dallas, Tex.

Grumman Aircraft Engineering Corp.
Bethpage, N.Y.

General Electric Co.
*Philadelphia, Pa.

Radio Corp. of America
*Princeton, N.J.

Bendix Corp.
*Baltimore, Md.

Boeing Co.
Seattle, Wash.

Space Technology Laboratories, Inc.
*Los Angeles, Calif.

International Business Machines Corp.
*Huntsville, Ala.

Brown Engineering Co., Inc.
Huntsville, Ala.

Hayes International Corp.
Birmingham, Ala.

Hughes Aircraft Co.
*Malibu, Calif.

Western Electric Co., Inc.
New York, N.Y.

Republic Aviation Corp.
Farmingdale, N.Y.

Lockheed Aircraft Corp.
*Marietta, Ga.

Motorola, Inc.
Scottsdale, Ariz.

Packard Bell Computer Corp.
Los Angeles, Calif.

Minneapolis-Honeywell Regulator Co.
*Hopkins, Minn.

Philco Corp.
*Philadelphia, Pa.

*Awards during period involve more than one location.

Appendix F

Research Grants and Contracts Initiated From Jan. 1 through June 30, 1962

	Type	Number	Total
ALABAMA: Southern Research Institute	Contract		$21,553
ARKANSAS: Arkansas, University of	Grant		20,511
ARIZONA: Arizona, University of	do	2	167,601
CALIFORNIA:			
Aeronutronic—Ford Motor Co	Contract		52,422
California, University of	Grant	8	1,905,586
California Institute of Technology	do	2	158,500
Douglas Aircraft Co., Inc	Contract		27,560
General Electric Co	do		60,597
Northrop Corp	do	4	262,715
Rand Corp	do	4	539,821
Space Technology Lab., Inc	do		63,574
Stanford Research Institute	do	5	256,353
Stanford University	Grant	2	284,665
Total			3,611,793
COLORADO:			
Colorado, University of	Grant		45,000
Denver, University of	do		24,000
National Bureau of Standards	Contract [1]	5	694,000
Total			763,000
CONNECTICUT:			
Connecticut Agricultural Experiment Station	Contract		28,704
United Aircraft Corp	do		125,733
Total			154,437
FLORIDA: Florida State University	Grant	2	115,369
GEORGIA: Georgia Institute of Technology	do	3	353,965
ILLINOIS			
Armour Research Foundation	Contract		28,520
Chicago, University of	Grant	3	356,896
Illinois, University of	do	2	173,127
Materials Research Lab., Inc	Contract		34,882
Total			593,425
INDIANA: Purdue Research Foundation	Grant		70,000
IOWA: Iowa State University	do	2	769,500

[1] Intergovernmental.

	Type	Number	Total
MARYLAND:			
Engineering Physics Co	Contract		$3,570
Hydronautics, Inc	do		45,850
Martin-Marietta Corp	do		98,867
Maryland, University of	Grant	3	306,376
Naval Medical Research Institute	Contract [1]		34,366
Total			489,029
MASSACHUSETTS:			
Advanced Metals Research Corp	Contract		46,513
American Academy of Arts & Sciences	Grant		181,000
American Meteorological Society	Contract		75,000
Boston University	Grant		12,608
Lessells & Associates, Inc	Contract		19,880
Harvard University	Grant	2	163,253
Massachusetts Institute of Technology	do	3	491,550
Do	Contract	2	199,400
National Research Corp	do		82,440
Tracerlab, Inc	do		16,190
Bolt, Beranek & Newman, Inc	do		56,074
Total			1,343,909
MICHIGAN:			
Henry Ford Hospital	Contract		11,700
Michigan, University of	Grant	4	329,800
Do	Contract	2	156,000
Wyandotte Chemicals Corp	do		61,099
Total			558,599
MINNESOTA:			
General Mills, Inc	Contract		73,820
Minnesota, University of	Grant	2	208,543
Total			282,363
MISSISSIPPI: Mississippi State University	Grant		92,615
MISSOURI:			
Midwest Research Institute	Contract	3	160,938
St. Louis University	Grant		17,880
Washington University	do		2,500
Total			181,318
NEBRASKA: Nebraska, University of	Contract		2,750
NEW HAMPSHIRE: Dartmouth College	Grant		49,906
NEW JERSEY:			
FMC Corp	Contract		96,364
National Beryllia Corp	do		65,000
Princeton University	Grant	2	254,600
Do	Contract		335,080
Total			751,044

[1] Intergovernmental.

	Type	Number	Total
New Mexico:			
New Mexico, University of	Grant	2	$60,923
New Mexico State University	do		188,435
Total			249,358
New York:			
Columbia University	Grant	2	84,897
Do	Contract		1,186
Cornell Aeronautical Laboratory, Inc	do		116,591
New York University	Grant	2	67,450
Rensselaer Polytechnic Institute	do	4	366,070
Republic Aviation Corp	Contract		161,599
Sperry Gyroscope Co	do		25,024
Syracuse University Research Institute	do		50,000
State University College of Education	do		9,600
Institute of the Aerospace Sciences	do		222,895
Total			1,105,312
North Carolina:			
Duke University	Grant	2	59,302
North Carolina, University of	Contract		22,620
Research Triangle Institute	do		56,028
Total			137,950
Ohio:			
AF, Bio-Acoustics Branch, Wright-Patterson	Contract [1]		116,060
Battelle Memorial Institute	do		35,000
General Electric Co	do	2	93,516
Ohio State University	Grant		100,000
Webb Associates	Contract		37,577
Total			382,153
Oklahoma: Oklahoma State University	Contract	3	18,925
Pennsylvania:			
Combustion Institute	Grant		20,000
Franklin Institute, The	Contract		67,000
General Electric Co	do	2	150,489
Mellon Institute	Grant		202,902
Pennsylvania State University	do	2	170,610
Eye & Ear Hospital of University of Pittsburgh	do		61,340
Total			672,341
Texas:			
Agricultural & Mechanical College of Texas	Grant	3	405,200
Graduate Research Center of the Southwest	do		923,000
Houston, University of	do		71,250
Rice University	do	2	237,900
Southwest Research Institute	Contract	2	95,432
Total			1,732,782
Utah: Utah State University	Grant		17,000
Vermont: Vermont, University of	do		33,720

[1] Intergovernmental.

	Type	Number	Total
VIRGINIA:			
Medical College of Virginia	Grant		$10,000
Melpar, Inc	Contract		27,775
Total			37,775
WISCONSIN:			
Wisconsin, University of	Contract	2	381,538
Do	Grant		700,000
Total			1,801,538
DISTRICT OF COLUMBIA:			
AF—Aerospace Medical Center	Contract [1]		200,000
Atomic Energy Commission	do.[1]	2	710,000
National Bureau of Standards	do.[1]	4	160,000
Catholic University of America	Grant	2	142,336
George Washington University	do		5,000
Navy:			
Bureau of Naval Weapons	Contract [1]	3	134,000
Office of Naval Research	do.[1]	2	129,400
National Science Foundation	do.[1]	4	110,000
National Academy of Sciences	Grant	4	444,000
Resources Research, Inc	Contract		175,043
Science Service	Grant		3,710
Smithsonian Institute	do		700,000
AF—Systems Command, Andrews AB	Contract [1]		25,000
Weather Bureau	do.[1]		50,000
Total			2,988,489
FOREIGN	Grant	4	249,800
Total half-year obligation			19,099,829

[1] Intergovernmental.

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